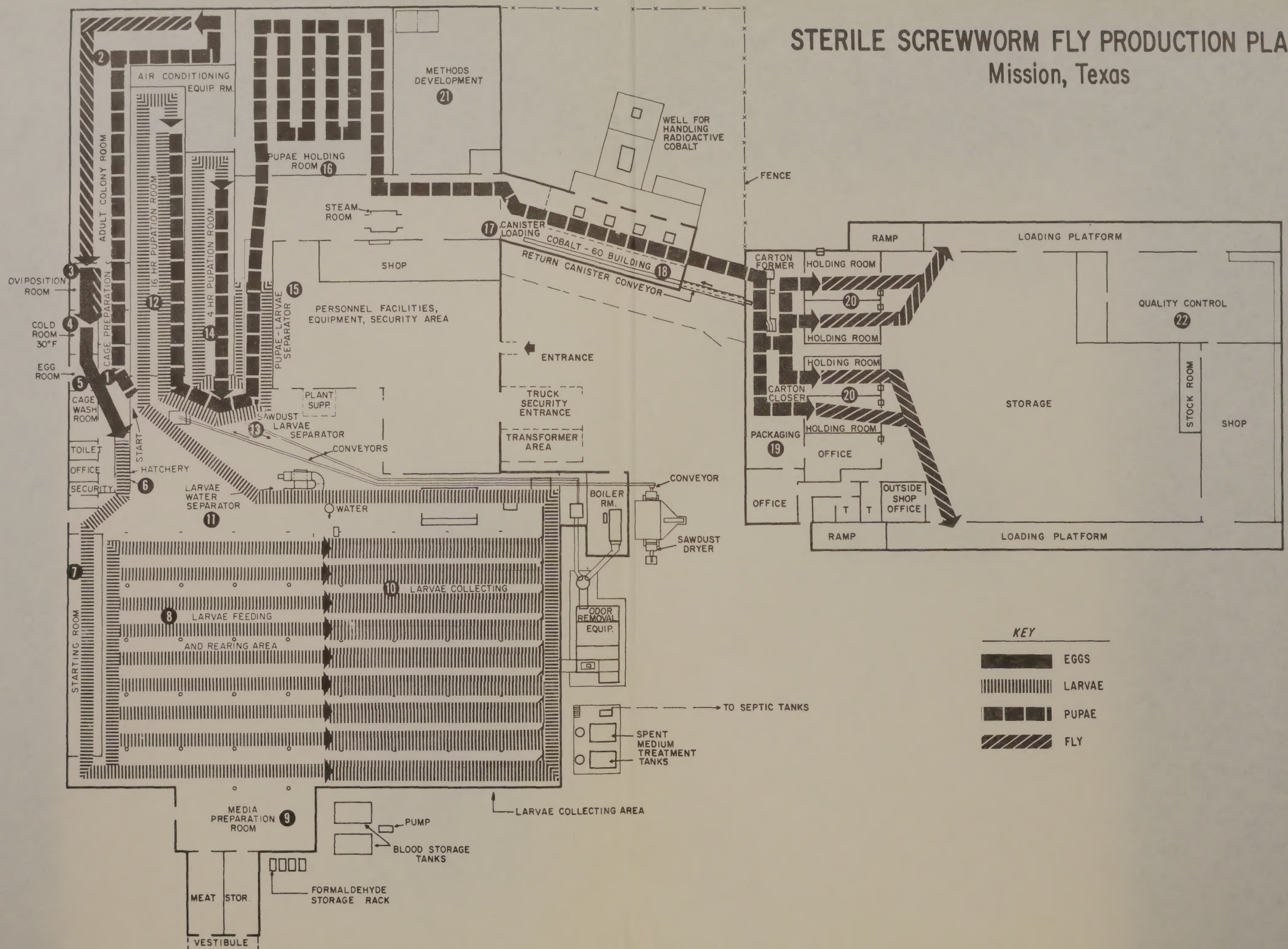






STERILE SCREWORM FLY PRODUCTION PLANT

Mission, Texas



THE STERILE SCREWORM FLY PRODUCTION PLANT MISSION, TEXAS

The Sterile Screwworm Fly Production Plant near Mission, Texas, is truly a "fly factory." It covers 81,500 square feet (1.87 acres), employs over 400 people working in three shifts every 24 hours for seven days a week, and is producing about 200 million sterile screwworm flies per week. Every operation is timed to coincide with the normal life cycle of the screwworm.

Cooperating in the program to wipe out the most costly pest confronting livestock producers are the Southwest Animal Health Research Foundation, the Texas Animal Health Commission, and the Animal and Plant Health Inspection Service of the U. S. Department of Agriculture backed up by the Agricultural Research Service. Informational and educational programs are conducted by Texas A&M University's Agricultural Extension Service and the Texas Education Agency's Division of Vocational Agriculture.

This plant was built entirely from funds invested by individual livestock producers and sportsmen in the Southwest. In one of the most intensive voluntary efforts in the history of the livestock industry, the Southwest Animal Health Research Foundation collected enough funds to make possible the completion of the plant much sooner than expected, at a cost much less than anticipated. This facility was made possible through voluntary efforts of the livestock industry and wildlife interests in the Southwest and North America.

(Note: The following description of the fly production plant has numbered sections coinciding with numbers on the attached floor plan to give the reader a clearer picture of how flies are reared, sterilized and readied for distribution.)

PLANT SECURITY

Security measures to prevent escape of any screwworm flies from the Production Plant are observed 24 hours a day. Escape of fertile flies would create a hazard to the program and result in costly setbacks.

Every crevice and opening in the main plant has been sealed. Plant security begins as workers or equipment enter the plant. Security measures are also employed inside the plant. Entrances for both men and equipment are controlled by one security guard on each shift. Workers come and go through the one entrance in the guard room. They pass into a locker room to remove street clothes, and then go unclothed through a vestibule into another room to dress in work clothes and shoes before entering the operational areas. All articles and clothing brought into the plant by workers must remain, be destroyed, or be placed in a 140-degree-hot room for 24 hours before removal from the plant is permitted.

Work clothes are washed in the plant each day. Each shift requires one laundryman, and 500 pounds of clothing are laundered each 24 hours. As workers leave, they must remove work clothes and shower before going into the locker room to dress in street clothes. All must leave through the guard room.

The guard also controls the truck entrance through which equipment and materials must enter. A truckload of equipment or materials entering the plant is driven into a screened vestibule before being unloaded. After the truck has been unloaded and has left the area, outside doors are locked. Equipment is brought into a security room and doors are closed. From there it is passed through a hot room and then into the plant. Material being removed from the plant must first be placed in the hot room where it remains for 24 hours at a temperature of 140 degrees F. Only then is it passed through the security room and the truck security entrance.

FLY PRODUCTION STARTS IN ADULT COLONY

Starting point for mass production of screwworm flies is the COLONY ROOM (2). About three to five percent of the pupae from the fly production of the plant is used for brood stock to provide eggs.

Workers in this section must pass through two security vestibules equipped with fly electrocutors to prevent fertile flies from entering the remainder of the plant.

In the CAGE PREPARATION ROOM, (1) large screen cages (3½' x 5½' x 6') are prepared to confine fertile flies that will produce eggs for mass production. Fly pupae are obtained from non-irradiated pupae production. Scores of paper streamers are hung from the top of each cage to increase the resting area of the emerging flies. The cage floor is paper lined, and 35,000 pupae are placed in trays and special food is provided for the adult flies when they emerge.

Cages are then moved through a security room into the colony rooms which hold 192 cages. The colony rooms are on a 12 hour day-night cycle and kept at a temperature of 80 degrees F. and 50 percent humidity. Emerging from pupae, flies find resting places on the paper streamers and sides of the cages. The flies remain here for about seven or eight days.

The cages are then passed through a curtain into the OVIPOSITION ROOM (3). At about 6 to 7 days of age, the females are ready to lay their eggs. An oviposition tray (5½' x 12" x 1¼" deep) containing especially prepared oviposition stimulant is placed in each cage. A built-in electric thermostatically controlled heating element keeps the contents of each tray at about 98 degrees F. A small wooden frame is placed on each tray with a light bulb to attract the flies to the eggging media. Females deposit their eggs on the wooden frame in small, neatly arranged masses of about 250 eggs each. Eight cages are egged and eight started every eight hours for a *200 million per week production level*.

After the flies have deposited eggs, each cage goes into the COLD ROOM (4), where exposure for a few minutes at temperatures of 32 to 36 degrees F. chills and immobilizes the flies. This permits removal of oviposition vats without escape of the flies.

In the EGG ROOM (5) egg masses are carefully removed. The cage is stripped of all paper, flies, and pupal waste which is destroyed in an incinerator. Cages are moved to a wash room to be thoroughly cleaned.

Egg masses are carefully weighed and 7 grams (140,000) eggs are placed on moist paper in a small container with a small amount of medium. This is held for about 12 hours in the HATCHERY (6). Newly hatched larvae are then passed into the STARTING ROOM (7).

LARVAE REARING

In the starting room, newly-hatched larvae are transferred to trays 13" x 18" x 2" containing a special starting food medium—a liquid medium consisting of dried blood, powdered dry cottage cheese, powdered milk, powdered egg, formalin and water. Racks containing trays for 10,000,000 larvae are placed in the starting room every eight hours. The new larvae are held in this room for 28 hours at a temperature of 100 to 103 degrees F. and 70 to 80 percent relative humidity. After this period, the larvae are transferred to new media in trays 18" x 26" x 4" and held at 94-97 degrees F. and 70 to 80 percent relative humidity for 12 additional hours.

Upon completing the starting cycle, the 40 hours old larvae are ready to be moved to the LARVAE REARING AND FEEDING AREA (8). This area has nine monorails, 26 racks per rail, and four vats per rack, for a total of 936 vats and 234 racks.

A liquid food medium, consisting of 6% spray dried blood, 3% powdered dry milk, 3% powdered egg, 2% powdered dry cottage cheese, 0.2% formalin and water, is placed on each vat. The vats (4' x 5' x 1¼" deep) contain a thermostatically controlled soil cable heating element that keeps the temperature of the feeding medium at 99 degrees F. Newly hatched larvae from the starting room are distributed over the medium in the vats.

For a production quota of 200 million, 92 vats containing approximately 140,000 larvae per vat are started every eight hours for a total of about 30,000,000 larvae yield every 24 hours.

In the MEDIA PREPARATION ROOMS (9), the liquid media is mixed with cotton in large steel mixing machines. The vats are carried by monorail to the media preparation area where the cotton and media mixture is pumped into the vats. Spent media is removed from the vats several times each shift through vacuuming and fresh medium is applied.

Approximate weekly feed requirements for 200 million larvae are: 11,000 pounds of dried cottage cheese; 17,000 pounds powdered egg; 16,000 pounds powdered milk; 32,000 pounds dried animal blood; and 12,000 pounds dried cotton.

On the fourth day many larvae complete feeding and begin to migrate from the vat to pupate. The racks are placed over the LARVAE COLLECTING AND WATER CONVEYING AREA (10). At the time larvae reach the collecting area, they are feeding near the edges of the vats.

The larvae-water conveying troughs are each eight inches wide and 75 feet long with a fall of six inches per 100 feet. Water travels 1¼ feet per second and carries the larvae to a common conveying trough.

Water used in conveying larvae is returned to a pump where it is reintroduced into the system with a small amount of fresh water added. Once each week the water is changed completely.

Spent medium, material left in vats after larvae have fed, is put in cooking kettles and heated to a temperature of 200 degrees F. for four hours to kill any remaining larvae. The spent medium is then pumped into a truck and buried in trenches on the plant grounds. Disposal water from the plant is piped into the sewage disposal plant.

A total of 120 hours elapse between the time larvae are placed in the starting trays and the vats are cleaned and sterilized in preparation for receiving the next batch of larvae.

Spent medium vacuum, air and water lines are located at regular points along the monorail system.

Odors produced by mass rearing of screwworm flies are controlled by removing 51,780 cubic feet of air per minute from the plant. This used air is pulled through a manifold located across one end of the building and into a stack which is 60 feet high and 66 inches in diameter. Fresh air, sometimes heated, enters the plant through manifolds at the opposite end of the building.

Water and larvae are siphoned from a collecting pit to the LARVAE-WATER SEPARATOR (11). After the water is removed, three liters of larvae—about 30,000—are placed in 26" x 18" x 4" measuring trays containing about eight liters of hardwood sawdust. Sawdust is stored and dried outside the plant and brought into the plant through the security room. After use, sawdust is conveyed to the incinerator for disposal.

LARVAE DEVELOP INTO PUPAE

Larvae placed in trays burrow into the sawdust to pupate. It is within the pupal shell that the transformation from maggot to fly takes place. Larvae begin to pupate after six

hours and continue up to 18 hours. A PUPATION ROOM (12) equipped with powered monorail system is maintained at a temperature of 80 degrees F. and relative humidity of 75 percent.

Pupation trays are placed on monorail racks that pass through the room in ten hours. Most of the larvae pupate in the final four hours of this period. At the end of the ten hours, the contents of the tray are placed in the SAWDUST-LARVAE SEPARATOR (13). The larvae and pupae are then conveyed to the PUPAE-LARVAE SEPARATOR.(15).

Separation of the larvae and pupae is accomplished by use of a unit employing an 18-inch continuous rubber belt that is 70 feet long. The belt passes under fluorescent daylight-type tubes with shades to produce graduated shadows. Larvae crawl away from the lights and drop through funnels into collectors and are placed in trays with sawdust. The trays are placed in the pupation room again for another four hours of pupation time before being separated again.

Pupae remaining on the belt in the larvae-pupae separator are collected and placed in trays with screened bottoms that are 18" x 26" x 2". The pupae are then placed in racks on a monorail system in the PUPAE HOLDING ROOM (16). Pupae are held in this room for five days at a constant temperature of 80° F. and relative humidity of 75%. Each rack and tray is marked with the pupation date.

RADIATION

Sexual sterility of all screwworm flies to be dispersed is accomplished by subjecting pupae to radiation from cobalt-60 which emits gamma rays. Five day old pupae from the holding room come into the CANISTER LOADING AREA (17). They are measured into stainless steel canisters which hold 3.8 liters or about 37,000 pupae. Aerated (or perforated) canisters are used to prevent the build-up of CO₂.

Six casks, containing cobalt-60, are placed on concrete pedestals in the COBALT-60 BUILDING (18). Any potential escape of rays at the time the units are opened to receive and discharge loaded pupae canisters can present no hazard to the operator.

An operator places each canister on a mechanical hoist that automatically carries it into position over one of the cobalt-60 casks. The operator does not again handle the canister. This is one of the security measures designed to guarantee that every pupa is irradiated before being removed from plant security. The gate to each cask is automatically opened and plugged when the canister is in position. The canister of pupae remains in the cask long enough to supply about 8,000 roentgens of radiation. The automatic equipment then removes the canister from the cask, the gate is closed, and the canister is dropped onto a conveyor that takes it to the PUPAE PACKAGING ROOM (19). Another conveyor returns empty canisters from the packaging room to the loading area.

Handling of canisters and pupae following the radiation process is safe because gamma rays pass through materials but leave no contamination.

Safety badges and radiation dosimeters are carried by each operator. Dosimeters are checked before and after each shift to insure against harmful radiation that might occur from improper operation or scatter radiation. Operators and visitors wear dosimeters in compliance with Atomic Energy Commission safety regulations.

To charge or perform major repair on the cobalt casks, the cask is removed from the pedestal using a fork lift truck and carried to a hoist that lowers it into a 13-foot well of water. Here, repairs or adjustments can be made under water, without danger from radiation.

PACKAGING THE PUPAE

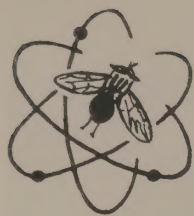
The carton assembly and packaging area provides storage for 1,000,000 flat paper cartons. The cartons, when folded, measure $5\frac{3}{4}$ " x $7\frac{3}{8}$ " x $4\frac{1}{2}$ ". They are assembled in a mechanical forming machine and the required number of pupae is dropped into each carton from an automatic dispensing machine. Then the cartons move along on a belt where workers insert a partition with a small cup of fly food. This assembly line can package 27 cartons of pupae per minute.

Cartons are manually closed, placed on trays and stored in portable racks in one of the several PRE-EMERGENCE HOLDING ROOMS (20) where the temperature is held at 45 to 75 degrees F., 80 percent relative humidity, for delivery by truck or plane to distribution centers. Flies may be held after emergence at 45 to 50 degrees F. for a day or two, or longer at these chill temperatures, if weather is unfavorable for dispersing cartons by aircraft.

The METHODS DEVELOPMENT (2) section, within plant security, is an important phase of the operation. Here studies are conducted to improve all phases of the eradication operation.

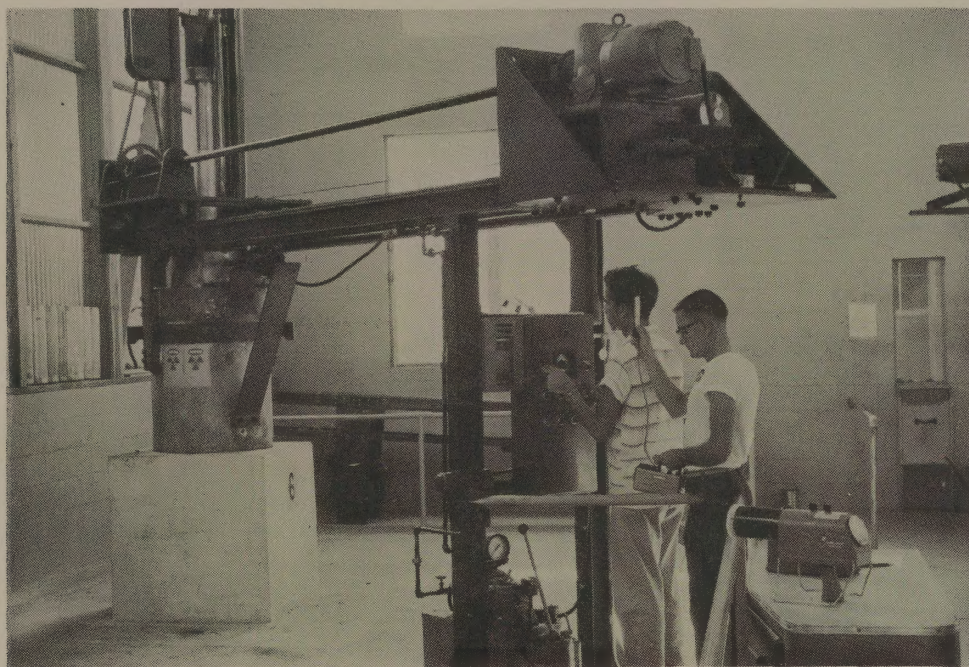
The QUALITY CONTROL (22) section provides a constant check on the mortality rate among flies, sterility, mating and other factors that indicate the effectiveness of program operations. Fifteen pupae are removed from each canister for a sterility check.

February, 1974



Atoms vs. the Screwworm No. 2

Progress report



N-30232—Irradiation of screwworm pupae in this cobalt-60 unit makes emerging flies sterile, but otherwise normal. Tests have shown that sterile males compete successfully with native screwworm flies in mating with females.

Efforts to eradicate the screwworm—an insect pest that causes livestock losses averaging \$20 million a year in the southeastern United States—are moving ahead on schedule. The program began July 11, 1958 with U. S. Department of Agriculture and the southeastern States cooperating.

Sterile screwworm flies—the key to the effort—are being reared, sterilized with radiant energy from cobalt-60, and released by air over the infested area. In 1958, flies were released over an area of 80,000 square miles in Florida, southern Georgia, and southeastern Alabama. This required a production rate of 50 million sterile flies per week.

Infestations have been confined almost entirely to southeastern Florida since December 1, 1958. The release of sterile flies plus winter weather have reduced screwworm populations in Florida and have apparently eliminated infestations in the other two States.

While screwworm populations are low in Florida and appearing in only limited areas there, it is important to use every measure to eliminate infestations, campaign officials say. The rate of release of sterile flies has been stepped up in Florida to further reduce the native fly population before warming weather favors seasonal migration of the insect. Livestock owners are asked to report screwworm cases and to treat infestations promptly with permitted smears such as EO-62 or EO-335 or the insecticide CO-RAL.

The eradication program is based on years of research by entomologists of USDA's Agricultural Research Service, who found that pupae of the screwworm exposed to the proper amount of radiation produce sterile flies. This led to the plan of using laboratory-reared and sterilized flies to reduce the population of the screwworms and eventually to eliminate the pest from infested areas. Tests showed that when native females mate with sterile males, they produce eggs that do not hatch. Mass liberation of sterile flies by air, at carefully timed intervals, eradicated the pest from the Caribbean island of Curacao in 1954. Tests in the vicinity of Orlando, Florida, in 1956-57 also gave promising results.

U. S. DEPARTMENT OF AGRICULTURE
Office of Information

Picture Story No. 116
March 1959

Magazines and newspapers may obtain glossy prints of any of these photographs from the Photography Division, Office of Information, U. S. Department of Agriculture, Washington 25, D. C. Others may purchase prints (8 x 10) at \$1.00 each from the same address.



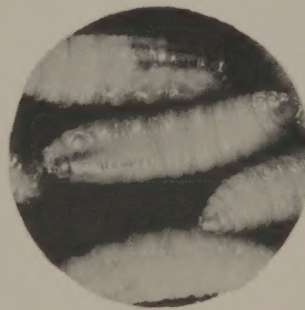
N-28623 - Airplane hangar 160 x 200 feet in size has been converted to a fully mechanized "assembly-line" type of mass-rearing screwworm plant at Sebring, Florida. All operations are synchronized to the life cycle of the screwworm.



Fly



Eggs



Larvae



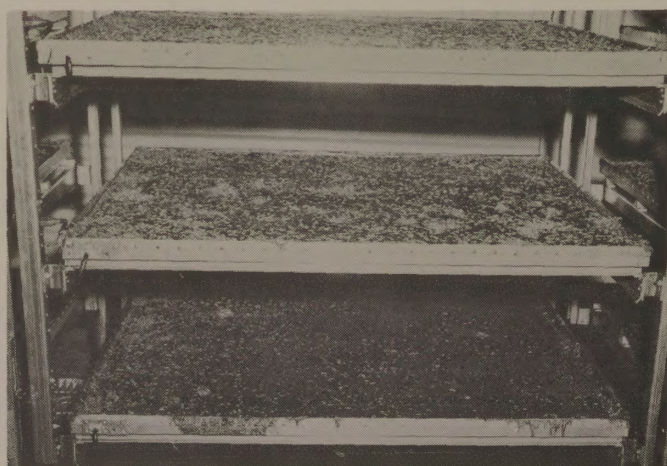
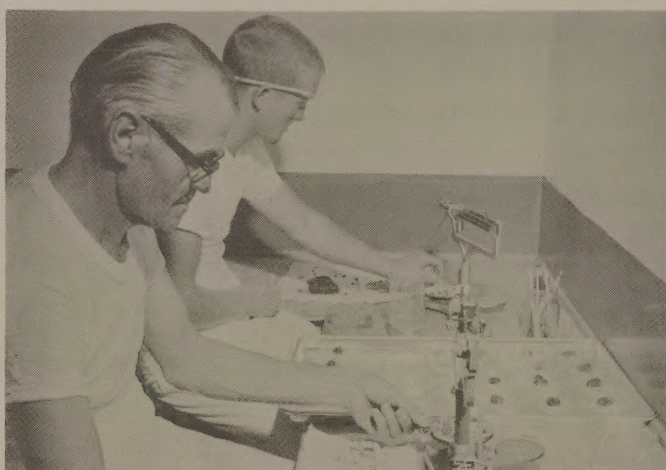
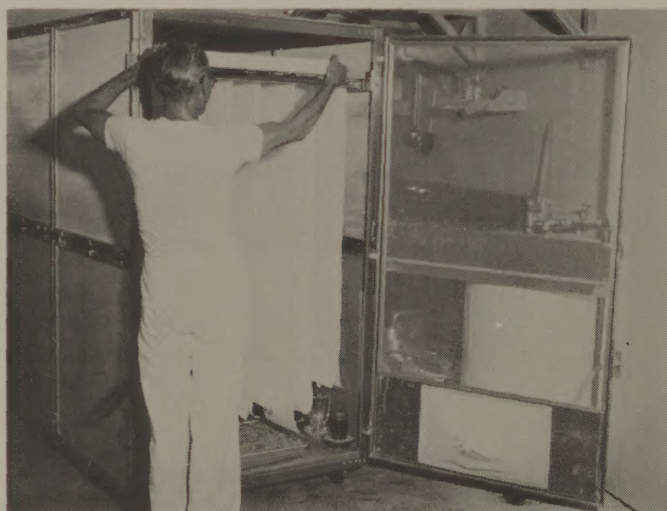
Pupae

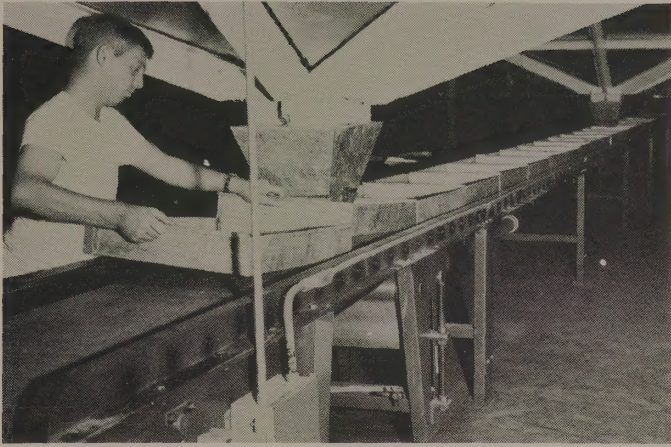
The screwworm fly (Bn 4384) is bluish-green in color and about twice the size of a housefly. The female lays about 250 eggs (Bn 4375) at a time on wounds of warmblooded animals. Larvae (Bn 1416) hatch from eggs and feed on animal, eventually killing it, if untreated. Grown larvae drop to the ground, burrow in the soil and change to pupae (Bn 4380). Flies emerge from pupal cases and come to the surface. The average life cycle takes about 21 days.

N-28631 - Mass rearing of screwworm flies begins here. Attendant readies a large screened cage for a fly colony. Fertile flies are induced to lay eggs on heated tray of ground meat in bottom of cage. Paper strips are hung for flies to rest on.

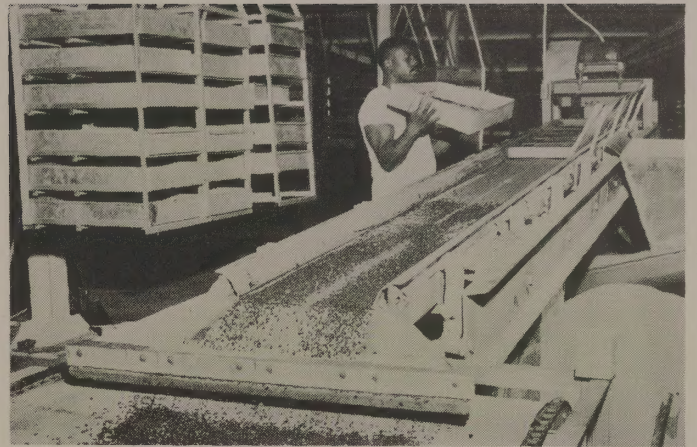
N-28635 - Five-gram lots of screwworm eggs (about 100,000) are weighed, placed on small piece of ground meat in covered dishes, and held in a hatching room. In about 16 hours larvae hatch and are ready to start new cultures.

N-30242 - Larvae are reared on meat, citrated blood and water in shallow, heated trays - - 3 per rack. The racks of trays travel for 5½ days on a powered monorail. As the larvae mature they crawl over the edge of trays and drop through metal grating in floor.

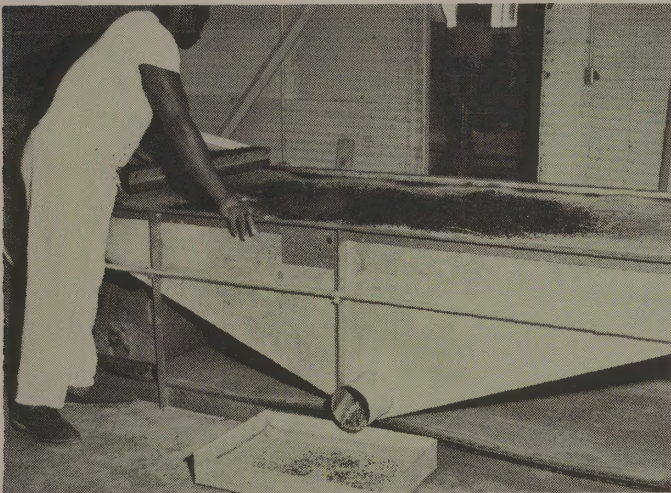




N-30257—Large metal hoppers beneath grates collect screwworm larvae and funnel them into sand trays on the lower floor. Moving on a conveyor belt, each tray catches about 18,000 larvae. Trays of larvae are then placed on racks hung from a powered monorail.



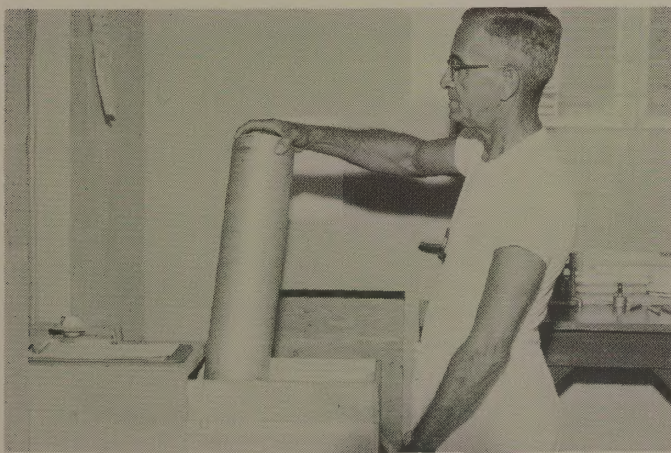
N-30246—Larvae burrow in sand and pupate during an 8-hour ride. As the racks of trays reach the sifter, an attendant dumps trays upon the sifter to separate pupae from sand.



N-30252—Pupae are then screened from remaining larvae. The larvae wriggle through the coarser screen and are funneled back into sand trays for another ride to complete pupation.



N-30250—Trays of 18,000 screwworm pupae are dated and stacked in racks hung from monorail. A 5½ day ride in a dark room held at 80°F. and 95 percent humidity readies them for irradiation. Here attendant examines color of pupae which change from light red to black as they mature.



N-30261—Screwworm pupae in metal canisters are transferred to the cobalt-60 room for irradiation. The canisters are passed through a safety drawer heated to 120°F. to kill any fertile flies that may have emerged.



N-28626—This building 32 x 76 feet houses the 6 cobalt-60 irradiation units. A minimum of 50 million pupae can be irradiated each week.



N-30226-Irradiated pupae move on conveyor belt to packaging room. Pupae are measured automatically into each box, boxes are closed mechanically, placed on trays, and then moved to holding room for flies to emerge.



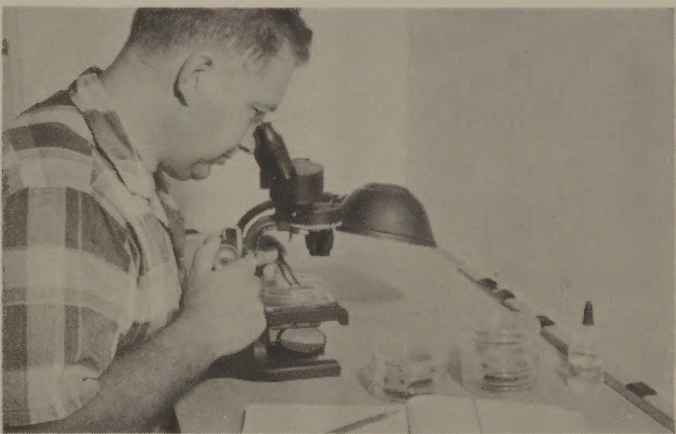
N-30221-About 1,000 cartons of flies are loaded on a plane. Plane is manned by a pilot and a man who feeds boxes into automatic releasing device and checks on its operation.



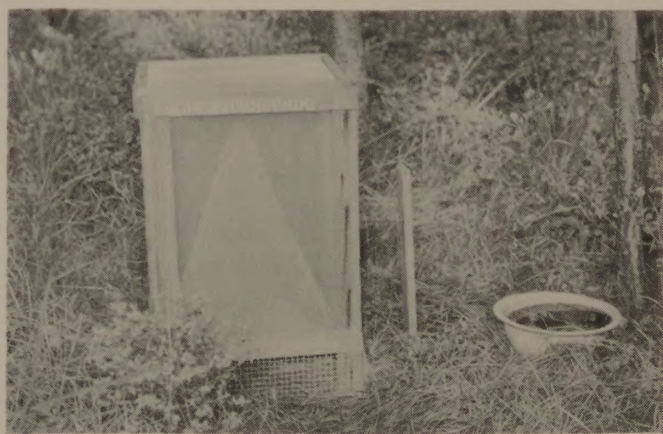
N-28349-Release rate of about 50 million flies a week requires 20 light planes flying about 5 to 6 hours daily. The planes leave from 4 to 6 dispersal centers and follow a pre-determined flight pattern. (Note box of flies released from plane in upper left.)



N-22044-Eggs and larvae collected from screw-worm-infested animals help to determine the number of sterile flies to be released in a given area. Livestock owners cooperate by reporting infestations in their herds.



N-21999-Entomologist examines egg masses from infested animals to determine whether eggs are fertile. Progress of eradication program is measured by reduction of fertile egg masses collected, among other methods.



N-24719-Specially designed traps baited with meat also provide a check as to activity of native and sterile flies. Each week inspectors patrol a line of 400 fly traps.

N-30264-To prevent spread of infestation northward livestock are treated with an insecticide before they may pass a State quarantine line across the northern part of the Florida peninsula. At Federal inspection stations on the eastern borders of Louisiana and Arkansas animals are inspected, wounds are treated with smear, or an insecticide is applied before they enter the southeastern screw-worm eradication area.



Screw-Worm Control

By R. C. BUSHLAND, Entomologist, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

NOT all maggots that infest wounds in cattle are screw-worms. A number of flies that breed in carrion also lay eggs, or in one special group, deposit already hatched maggots in wounds. But these carcass breeders ordinarily are found in old, pussy, infected wounds, whereas the screw-worms attack living tissue. All the screw-worm needs to get started is a break in the skin which may be caused in various ways.

The navel of a new-born calf is a favorite spot for the screw-worm fly to

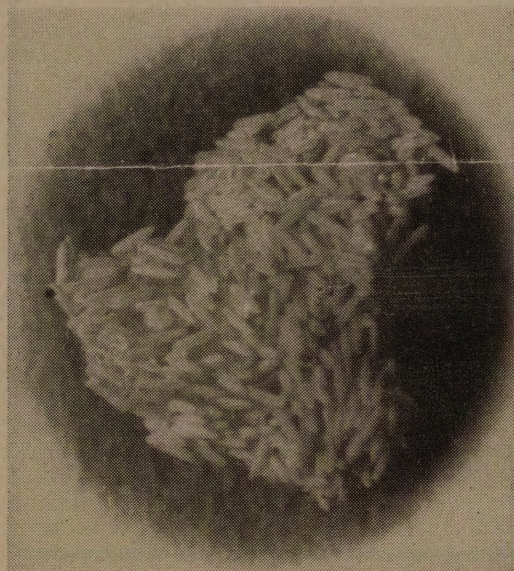


Figure 1. Three masses of screw-worm eggs.

lay eggs. It also likes castration wounds, brands, cuts, pink-eye cases, scratches, and will even hunt out such small wounds as fly and tick bites to lay her eggs.

The screw-worm fly lays tiny, white eggs in shingle-like masses, usually about 200 at a time. Figure 1 shows three egg masses laid by three flies that selected the same spot on which to oviposit. No other wound-seeking fly arranges her eggs so carefully or lays such white eggs. Ordinary blow fly eggs are yellowish and just piled in a heap. If you see pure-



Figure 2. A full-grown screw-worm maggot.

white, shingle-like eggs laid in flat masses on the edge of a wound, it is a sure sign that screw-worms are after your cattle. The speed of hatching depends on how warm the weather is, but usually the eggs hatch in 12 to 24 hours. The little maggots are covered with dark-colored spines, which can be seen through the egg shell just before the eggs hatch, making them look gray.

The little maggots immediately start feeding on the live tissues of the wound. Each stands on its head and rasps at the flesh with its mouth hooks. The spines that cover its body keep it from slipping out of the wound. Two air tubes (called tracheae) open at the rear end of

its body, and when it needs a breath of fresh air it backs up far enough so that the tube openings (called spiracles) are above the fluid in the wound.

The maggots feed as a colony and develop rapidly, becoming full grown in about six days. In that time the progeny of one fly have eaten a hole as big as a lemon and each maggot has grown to a length of a little more than one-half inch. After the maggots have been in a wound for two or three days, it is easily recognized as a screw-worm wound because of the profuse brownish-red, bloody liquid that drains out of the wound and stains the hair below it. The characteristic odor also serves to distinguish screw-worm infestations. An infested wound almost always attracts other flies to oviposit; so freshly laid white egg masses on the margins of the wound also warn the cattleman that he has screw-worms to contend with.

There is one more sure way to identify a screw-worm case. Figure 2 is a magnified picture of a full-grown screw-worm. At the left is the pointed head with its mouth hooks. Notice the rows of spines that surround the body, giving it the screw-like appearance from which it derives its name. The head and spines are not greatly different from those of carrion-feeding maggots, but two other features are distinguishing. Notice at

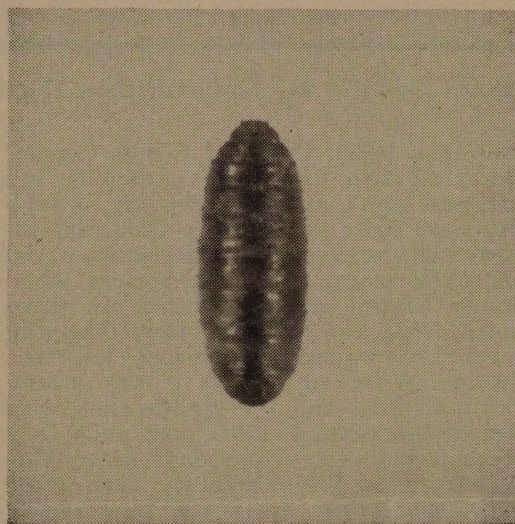


Figure 3. A screw-worm pupa.

the tail end that the two breathing tubes are so dark that they show up as two black lines through the almost transparent skin. The screw-worm is the only maggot you will find that has those heavily pigmented tracheal trunks showing as a pair of dark, straight lines.

Another feature that does not show in the picture is the color of the grown screw-worm. Maggots that breed in carcasses are whitish, yellow, or grayish, but the screw-worms have a pinkish color when they are about through feeding and ready to leave the wound. The pink color and straight, dark air tubes are a sure combination to identify a grown screw-worm. The pair of straight air tubes show up even in the younger maggots before the pink color develops.

The pink maggot crawls out of the wound and falls to the ground, where it quickly burrows into the soil. It shrinks

up its body and the skin hardens into a pupal case which surrounds the insect. At first the case is a pale brown color, but in a few hours it turns dark brown. Figure 3 is a picture of the screw-worm in the pupal stage, in which it changes over to a fly. In very hot weather this change takes place in about a week, but in cooler weather the pupal stage may last as long as 12 weeks, but usually much less time. The pupae cannot stand prolonged exposure to cold weather and in northern areas even the pupae in the ground are killed by cold.

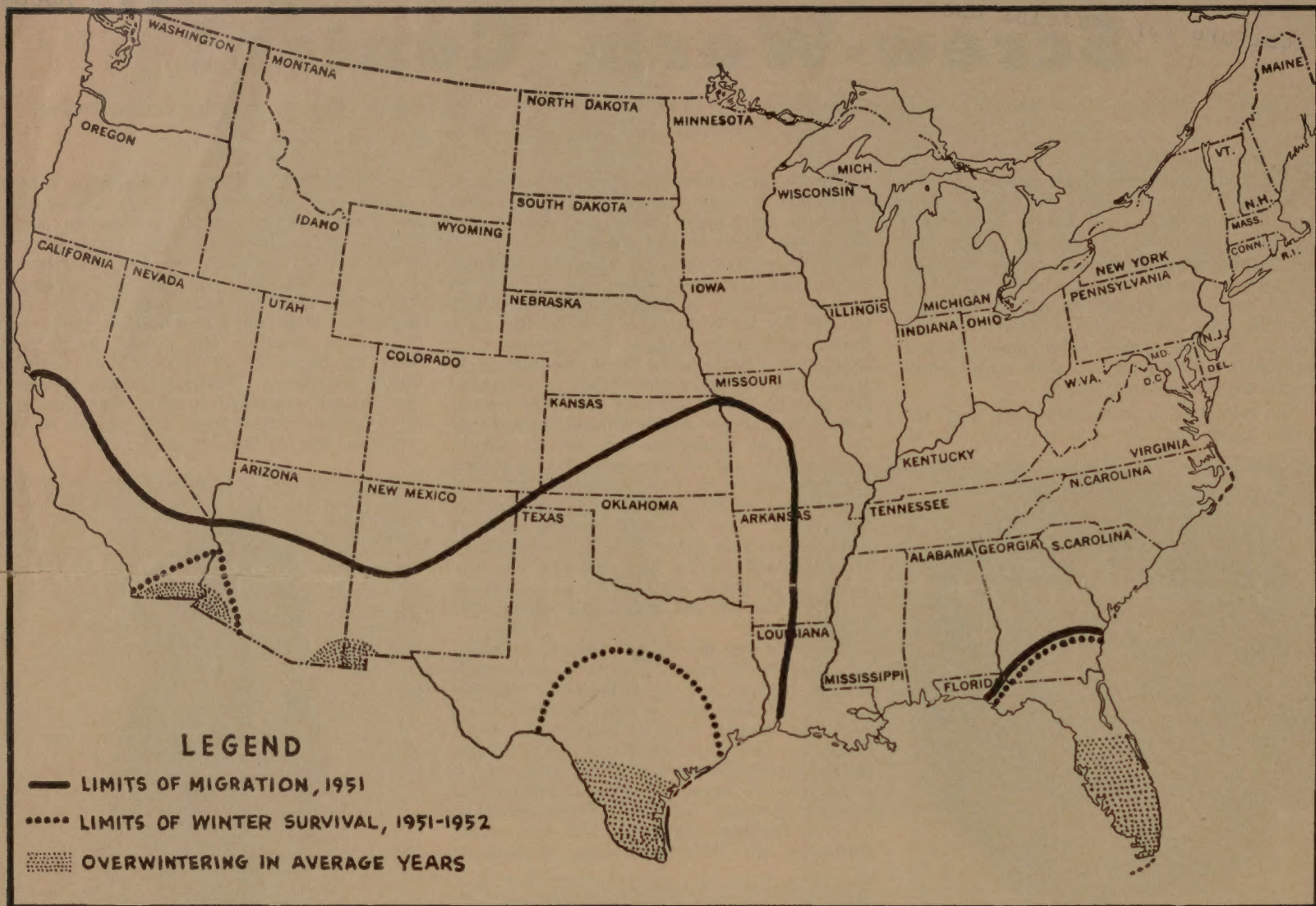


Figure 4. A female screw-worm fly.

The fly breaks open the pupal case underneath the ground and wiggles up through the soil to the surface, where it climbs up on a blade of grass, weed, or twig and stretches out and dries its wings. Within an hour it is able to fly away.

Figure 4 is an enlarged picture of a female screw-worm fly. There is nothing particular about its appearance that distinguishes it from an ordinary blow fly. It is bluish in color and looks very much like the secondary screw-worm fly which breeds in carcasses and causes summer fleeceworm cases. Only expert entomologists can readily identify the screw-worm fly, and sometimes they need a microscope to be sure. The screw-worm fly does not lay eggs as soon as it comes out of the ground. When the insects are two or three days old they mate, but the female is not ready to lay eggs until she is six days old, and in cool weather more time than that is required for her to develop her eggs. After laying her first batch of eggs, the female is capable of developing still more egg masses and ovipositing for two or three more weeks, when she dies of old age.

Screw-worms are not true natives of temperate America. They live the year around in the warm parts of South America, Central America, Mexico, and in the United States only in areas ad-



Screw-worm areas in the United States, 1951-1952.

joining Mexico and in Florida. In mild winters they may live farther north, and in extremely cold winters they are crowded down to the southernmost margins of the country. In the summertime when temperatures are favorable they spread northward under their own wing power at the rate of about 35 miles per week; so southern cattlemen are well acquainted with them.

Sometimes, through shipment of infested livestock, screw-worms are accidentally introduced into areas far north of their ordinary summer migrations. In Iowa, Illinois, South Dakota, Indiana, and New Jersey they have appeared unexpectedly and have done tremendous damage before the native cattlemen in those areas learned to recognize and control them. Therefore, it is very important for every rancher in the more northern states to be able to recognize a screw-worm case and notify his local agricultural officials immediately if he finds one. Three years ago screw-worms got started near Pierre, South Dakota, and did tremendous damage that summer because they were new to the area. Last year cattle infested with screw-worms were shipped into the same town, but the infestation was recognized right away and local authorities wiped it out before it ever got started.

Recalling the life cycle makes it clear why even one overlooked screw-worm case can cause an outbreak. Suppose that a cow gets scratched in loading for shipment from a screw-worm area to a northern state. On that scratch one fly can lay 200 eggs which might not be noticed,

and they hatch in about a day. During the first two days after hatching the maggots don't make a very big wound. Suppose that during this time the infested cow arrives at its destination and the little worm case isn't noticed when she is turned out to pasture. In three more days the worms start dropping from the wound and crawl into the ground. After eight days in the ground 100 male flies and 100 female flies come out of the ground. After two days they mate, and three or four days after mating there is the possibility that those 100 females can start 100 new screw-worm cases. All this increase takes place in just three weeks. In another three weeks the offspring of that first generation could start 100 times 100, or 10,000 cases. In another three weeks there is the mathematical possibility of 1,000,000 cases, just two months after the one unnoticed worm case was turned out to pasture.

Of course, the rate of increase doesn't equal the mathematical possibilities. Such insects as ants eat many of the maggots, pupae, and even the flies when they first come out of the ground and are not yet able to fly. Spiders and birds catch some of the flies. Unfavorable weather kills some of the adults before they are old enough to lay eggs. After the eggs are ready for laying the fly must first find a wounded animal. But the possibilities for screw-worm build-up are tremendous and emphasize the importance of the stockman recognizing,

treating, and preventing screw-worm cases.

We cannot tell for sure what the screw-worm situation will be this summer. Because of the mild winter the insects survived much farther north in Texas than usual. North Texas and Oklahoma ranchers can look for screw-worms to bother them earlier this year. The Bureau of Entomology and Plant Quarantine conducts an annual screw-worm survey. C. L. Smith, H. M. Brundrett, and W. D. New study screw-worm conditions in the western states, and A. L. Smith and C. C. Skipper keep track of screw-worms in the Southeast.

On the accompanying map the top heavy line shows how far north screw-worm cases were found in the United States during the summer and fall of 1951. The broken line marks the limit of overwintering in 1951-52. The shaded areas are those in which screw-worms usually survive the winter.

Since the end of World War II the Bureau's laboratory at Kerrville, Texas, has worked on development of wound treatments to utilize the new chlorinated hydrocarbon insecticides, of which DDT is the most famous example. Kerrville research workers, led by G. W. Eddy, found that DDT was not such a good screw-worm killer as they had hoped, but a newer chemical called lindane was outstanding. They found that 3 percent of lindane dissolved in 35 percent of pine oil with thickening and penetrating agents added made an outstanding wound treatment. The new medicine was

called EQ-335 to stand for the 3 percent of lindane and 35 percent of pine oil. This new treatment was recommended to the insecticides industry late in 1950 in plenty of time for manufacturers of veterinary products to make and distribute it for the 1951 screw-worm season. Our experimental work indicated, and stockmen who used it last summer confirmed, that using EQ-335 makes screw-worm control easier and better.

EQ-335 is applied just like the old smear 62, with a small paint brush to pack the wound full of the medicine and daub a little around the edge. The old smear 62 had to be applied twice a week. The new EQ-335 is longer lasting, and it will protect most wounds if applied once a week until they are healed. Really bad wounds should be treated twice the first week, because during the first couple of days after treatment dead maggots and worm eaten tissues are sloughed out of the wound in such quantity that they sometimes carry most of the protective medicine along with them, but for ordinary screw-worm wounds once a week is sufficient.

EQ-335 has an advantage far more important than reducing the number of treatments required. This outstanding feature is the fact that the lindane deposit on the wound is deadly to flies. The old smear 62 and most other treatments killed the maggots, but had no effect on the adult flies that subsequently visited the wound to lay eggs or to feed on the exudate. Flies could light on a treated animal and then fly to another to start a new screw-worm case. When a wound is treated with EQ-335 once a week, it becomes a deadly fly trap. The treatment does not keep flies away, but

all that crawl on the treated area soon die. We think that if all ranchers use a screw-worm remedy that has residual fly-killing properties, such as EQ-335, they will notice the benefits in reduced worm cases.

Female screw-worm flies especially like to come to wounds just to eat the blood and serum before they are ready to lay eggs. This is why we believe that by treating with EQ-335 ranchers will not only heal out existing cases more easily, but will also prevent many new cases.

Some of you may have read about new research the Bureau of Entomology and Plant Quarantine is doing with sterilized flies. Those experiments have no practical application for screw-worm control this summer, but are part of a long-term research project aimed at trying to eradicate screw-worms from the southeastern states. Screw-worms first became established in the Southeast in 1933, probably through shipment of infested livestock. They found the climate of southern Florida suitable for overwintering and each summer they spread north from there.

In laboratory experiments at Kerrville, we found that female screw-worms mate only once. Tests were conducted to determine whether screw-worm flies could be sterilized and to measure the effect of mixing populations of sterilized and normal flies. The experiments showed that screw-worms could be sterilized with either x-rays or gamma rays produced from radioactive cobalt, and that if a normal female fly mated first with a sterilized male she would not mate again and would lay only infertile eggs for the remainder of her life.

In tests with screw-worms in cages we found that, when we outnumbered normal insects by releasing greater numbers of sterile flies in the same cages, most of the normal females laid infertile eggs. Our organization is now conducting a small-scale field test on an island off the coast of Florida to see how the project works under natural conditions.

It is relatively easy to produce sterilized screw-worm flies. Any number can be reared in the laboratory using wash tubs containing a medium composed chiefly of hamburger meat and blood, which is kept at body temperature while the maggots are growing. The insects are sterilized in the pupal, or resting, stage. The pupae are merely poured into a suitable container and exposed to the sterilizing radiations. After the flies emerge from the pupal cases they act like normal flies in all respects except that they are infertile.

Many field experiments must be conducted before we can decide whether screw-worm eradication through release of sterilized flies would be practical. We think it might be, but only in Florida where there are not many screw-worms in the wintertime and where they are isolated from other screw-worm flies. We cannot plan on such a method for the western United States, because screw-worms overwinter at places all along the Mexican border from Texas to California and even down into South America. So western stockmen will have to depend on good animal husbandry and proper wound treatment for screw-worm control. Southeastern stockmen will have to follow the same procedures while more research is being done.



With Sterility Technique

Screwworms Eradicated from U.S.

THE SCREWORM has been eradicated from the United States.

This marks the first time that a wide-ranging insect species has been eliminated from this country using sexual sterility as the eradication tool. The screwworm literally was caused to destroy itself.

Less than a decade ago, screwworms were one of the most serious livestock parasites in the United States, causing annual losses of up to \$100 million to domestic animals and untold losses in wildlife. Historically, the insect has menaced warm-blooded animals throughout the Southern United States, spreading northward during warm seasons.

Eradication came after 5 years of intensive State-Federal effort in two separate campaigns: In the Southeastern United States during 1957-59, and in the Southwest from 1962 to the present. About \$32 million went for eradication and protection costs—about one-third the cost of damage that screwworms can cause in one bad year.

Weapons for the battle were acquired when ARS entomologists discovered a practical way to sexually sterilize screwworms and learned how to raise them in large numbers. ARS veterinarians applied these laboratory findings to the large-scale eradication campaigns involving the release of more than 20 billion sterile

screwworm flies to cause infertile matings and eventually eliminate the native population.

These campaigns required mass production of insects on a scale never before attempted. The huge production plant now operating at Mission, Tex., is a marvel of biological mechanization tailor-made to fit the screwworm's life cycle. The plant employs around 300 persons and operates 24 hours a day to produce up to 150 million sterile screwworm flies each week. Screwworm larvae can devour, each week, around 70 tons of meat and 12,000 gallons of blood. They are sterilized in the pupal stage by exposure to radioactive cobalt. The pupae are packaged in cartons where they develop into flies, then released from aircraft.

This spring, California and Arizona were declared free of established screwworm populations, thus making the entire United States free of established native screwworms. But migrating screwworms from Mexico cause concern. The screwworms' explosive ability to multiply and spread makes it vital to detect migrant infestations early to prevent establishment of the insect.

To protect the Southwest from Mexican screwworms a barrier has been established through release of millions of sterile screwworm flies

over Northern Mexico. Barrier activities, cooperatively carried on with the government and livestock producers of Mexico, have lessened screwworm damage in northern Mexico and stimulated interest in extending the campaign.

Livestock producers of the Southwestern United States and Mexico have formally requested that both countries conduct a joint screwworm eradication program in Mexico. They point out that such a program would better protect screwworm-free areas of the United States, and cut costs of operating the barrier, which could then be established across a narrower section of Southern Mexico.

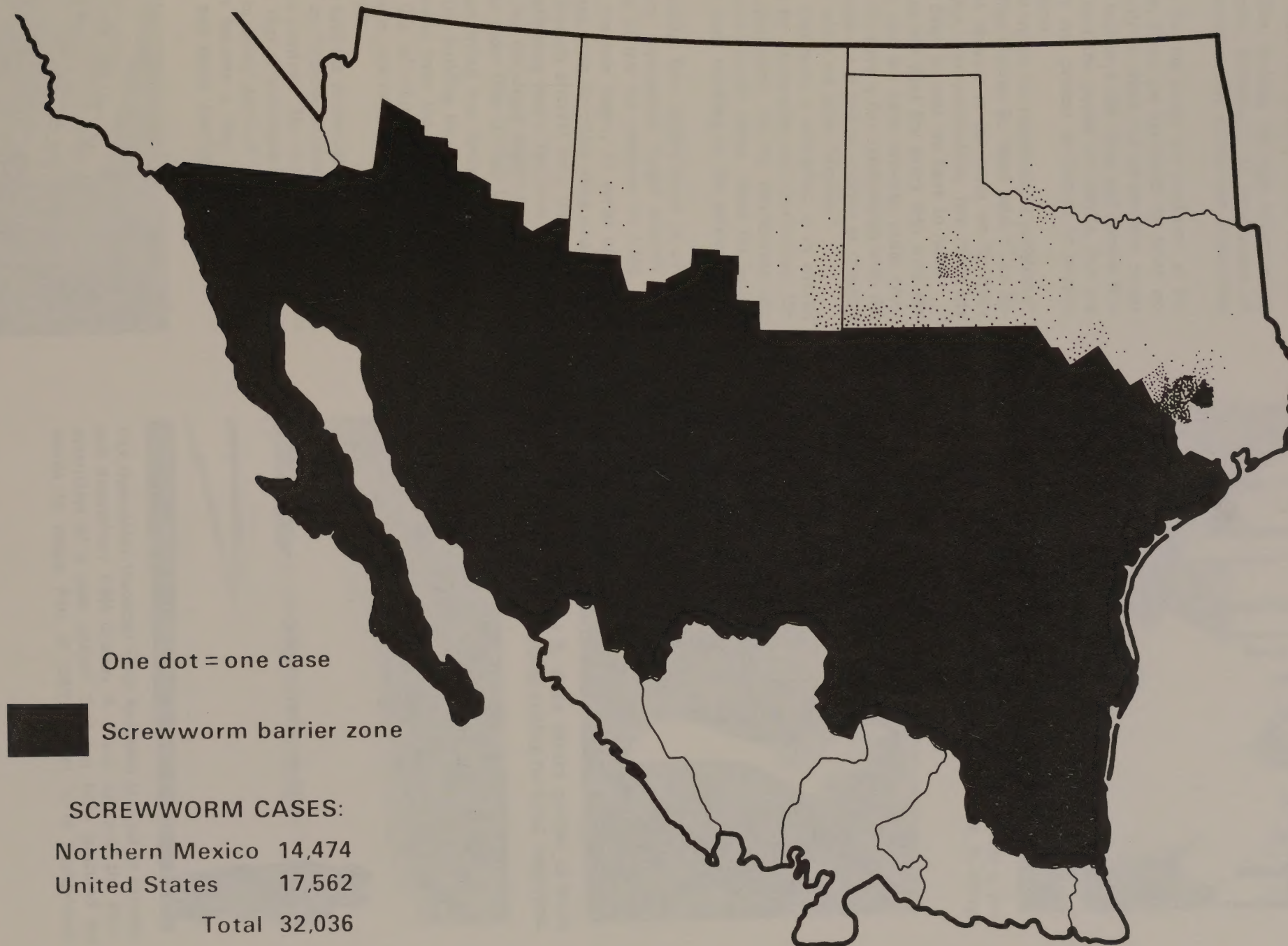
The success of screwworm eradication in the United States has stimulated research on turning the sterility concept—using either irradiation or chemicals—against other insect pests. It has helped wipe out the melon fly on the Pacific Island of Rota and the oriental fruit fly on Guam. It is in use along the California-Mexico border against the Mexican fruit fly, and researchers in Egypt, Israel, and Central America are trying it against the Mediterranean fruit fly. And in Africa, scientists are testing the sterility technique against the tsetse fly, a pest that spreads sleeping sickness and retards development of major portions of Africa. ■



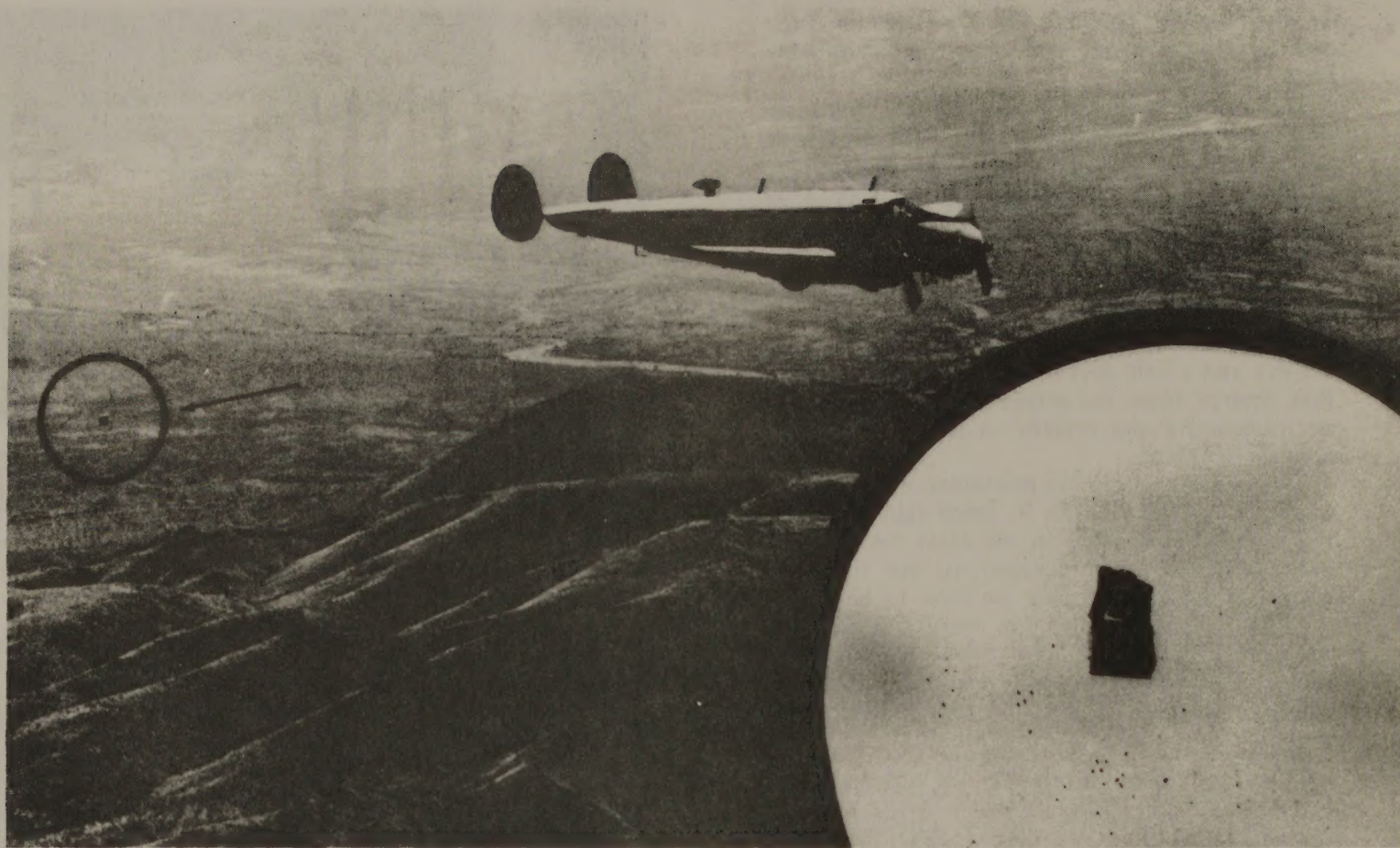
The screwworm rearing plant at Mission, Tex., can mass-produce up to 150 million sterile flies per week. (Photo No. BN-24921)

CONCENTRATION OF LABORATORY CONFIRMED SCREWORM CASES

United States - Northern Mexico, Calendar Year 1975



Dr. W. T. Gartman, overall administrator for the Animal Health Division operation at Mission, studies map of Mexico to pinpoint his pilots' next drops.



A C-45 drops a box of flies over infected area in Mexico. The C-45 carries 1,000 boxes of flies, while the larger DC-3s will accommodate 4,000 boxes.

FAA USDA Airdrops Say...

"Don't Bug Me!"

By George Burlage

MISSION, Tex.—"It's a great operation, and for me it is a pleasure to work with such professional people."

That is the summation by FAA's Erick Andreson concerning a unique operation run by the U. S. Department of Agriculture's Animal Health Division here at Mission—airdropping sexually sterile flies into Mexico to wipe out animal pests.

Andreson is an operations inspector in the San Antonio GADO.

A successful aerial battle has been waged for the past six years in the expansive South Texas area. It has now crossed the border into Mexico, hopefully to deal a death blow to the enemy of all types of livestock.

The tools of the battle are aerial drops of the sterile flies; the goal is complete eradication of a parasite that causes millions of dollars in livestock and game animal losses annually—the screwworm.

From the former Army airfield at Mission, the Agriculture Department has set up a squadron of

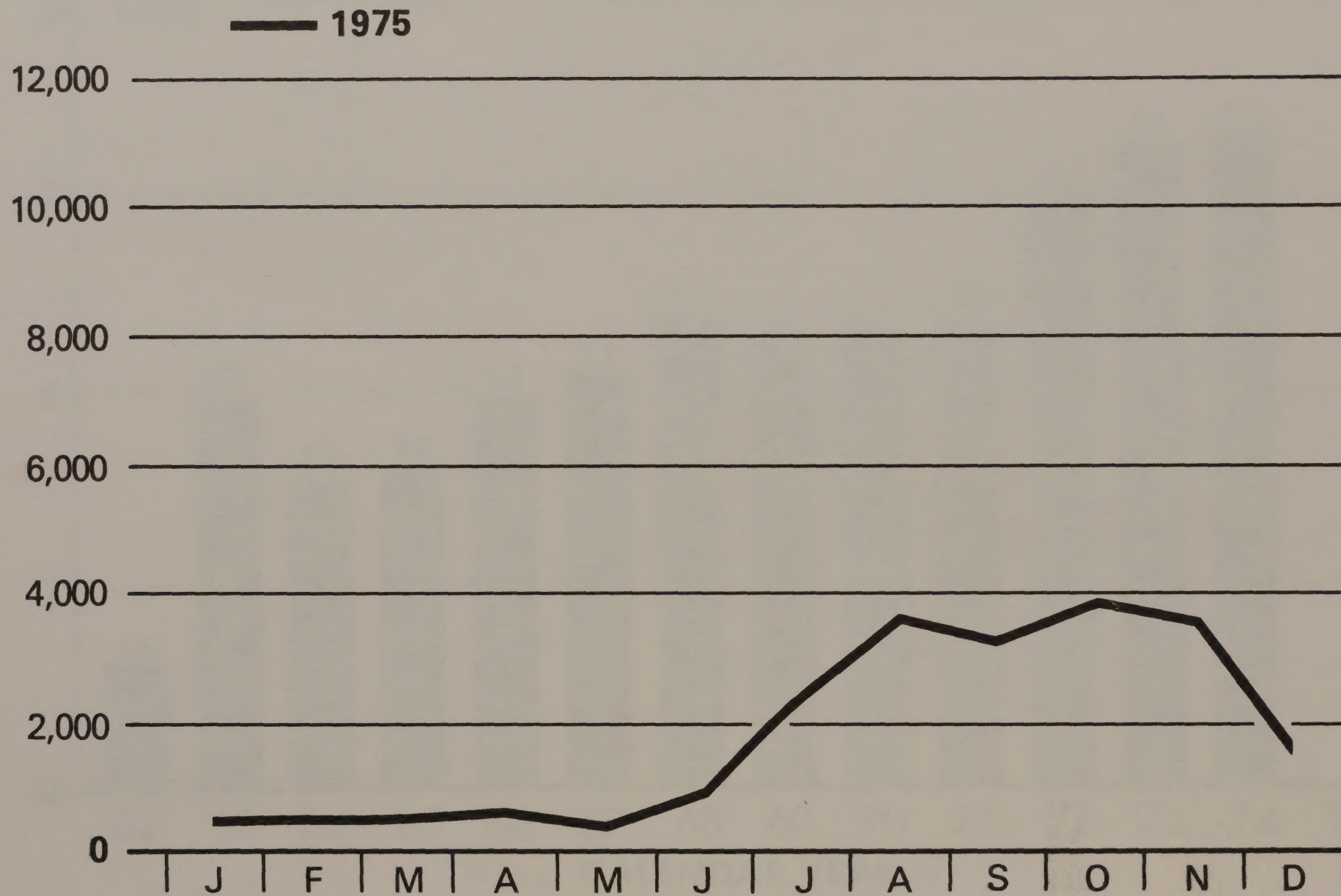
26 aircraft, including Beavers, Pipers, C-45s and C-47s to bombard parts of Mexico daily with fly drops. Another six aircraft operate from Douglas, Ariz., to cover the western part of Mexico.

These drops deliver from 108 to 125 million sterile flies weekly to form a barrier that keeps the parasite from moving northward into the United States. At present the barrier extends from the Gulf of Mexico 2,000 miles to the Pacific and varies in width from 300 to 500 miles.

When the project first started, aerial drops were made principally in Texas and along the border on the United States side to eliminate the screw-worms in these areas. The frontier has been pushed into areas of Mexico where the parasites are being wiped out gradually as pilots systematically fly a grid to drop the flies. Special drops are made in isolated areas of heavy infestation.

Screwworms are a destructive parasite of warm-blooded animals. The flies lay their eggs in the open wounds of domestic and wild animals and in man. Larvae hatch in the wounds and destroy

MEXICO SCREWWORM CASES *



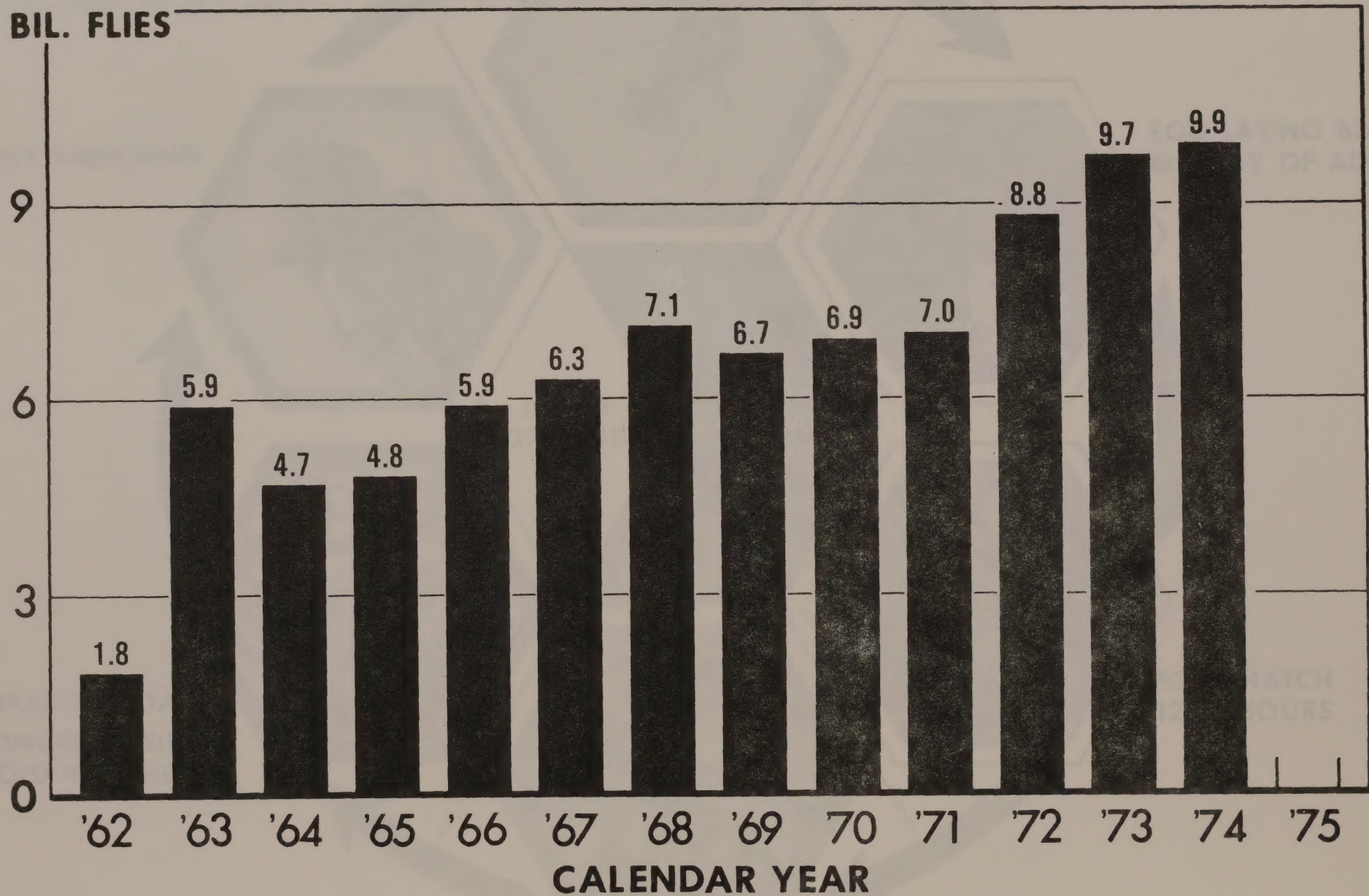
* laboratory confirmed

U.S. Department of Agriculture

Veterinary Services

Animal and Plant Health Inspection Service

SCREWWORM STERILE FLY RELEASE



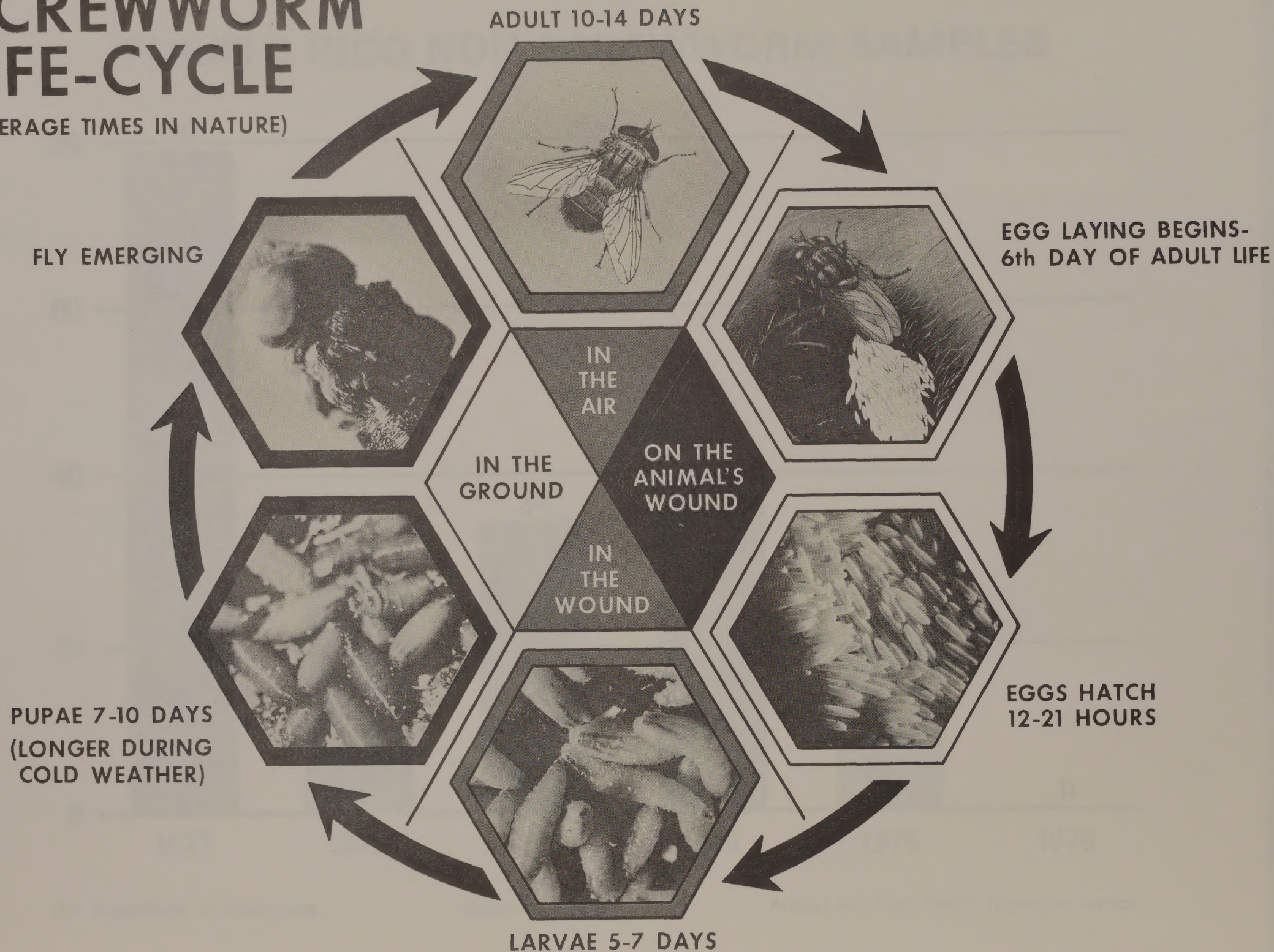
U.S. DEPARTMENT OF AGRICULTURE

VETERINARY SERVICES

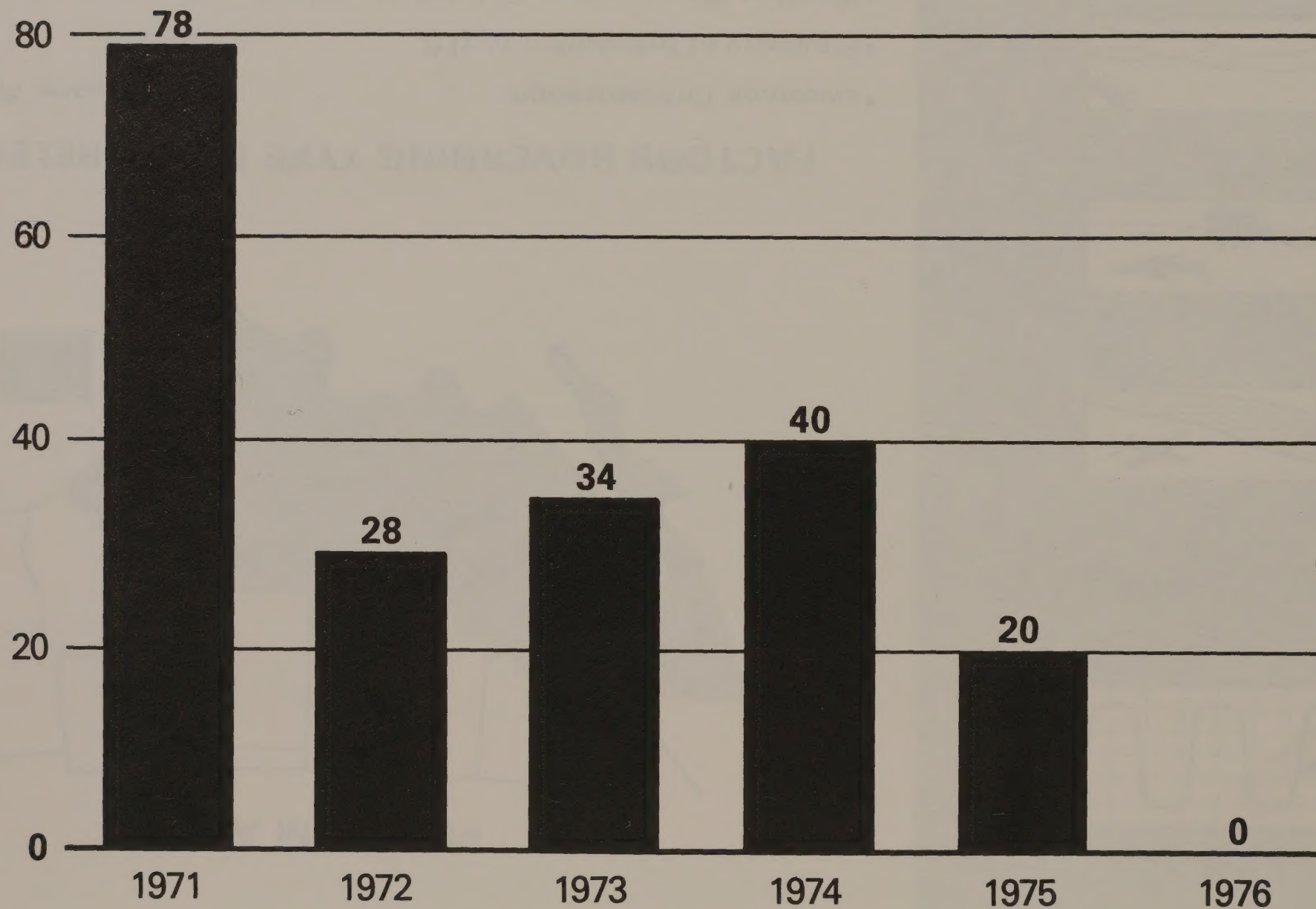
ANIMAL AND PLANT HEALTH INSPECTION SERVICE

SCREWWORM LIFE-CYCLE

(AVERAGE TIMES IN NATURE)



PUERTO RICO NON-SCREWWORM SAMPLES



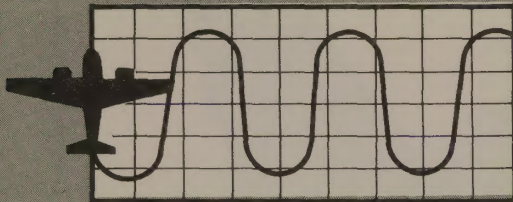
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Animal and Plant Health Inspection Service

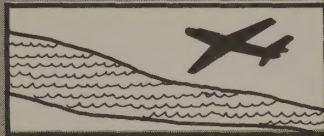
USE OF STERILE FLIES IN PROGRAM AREA

GRID RELEASE



STRATEGIC RELEASE

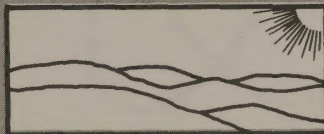
•River



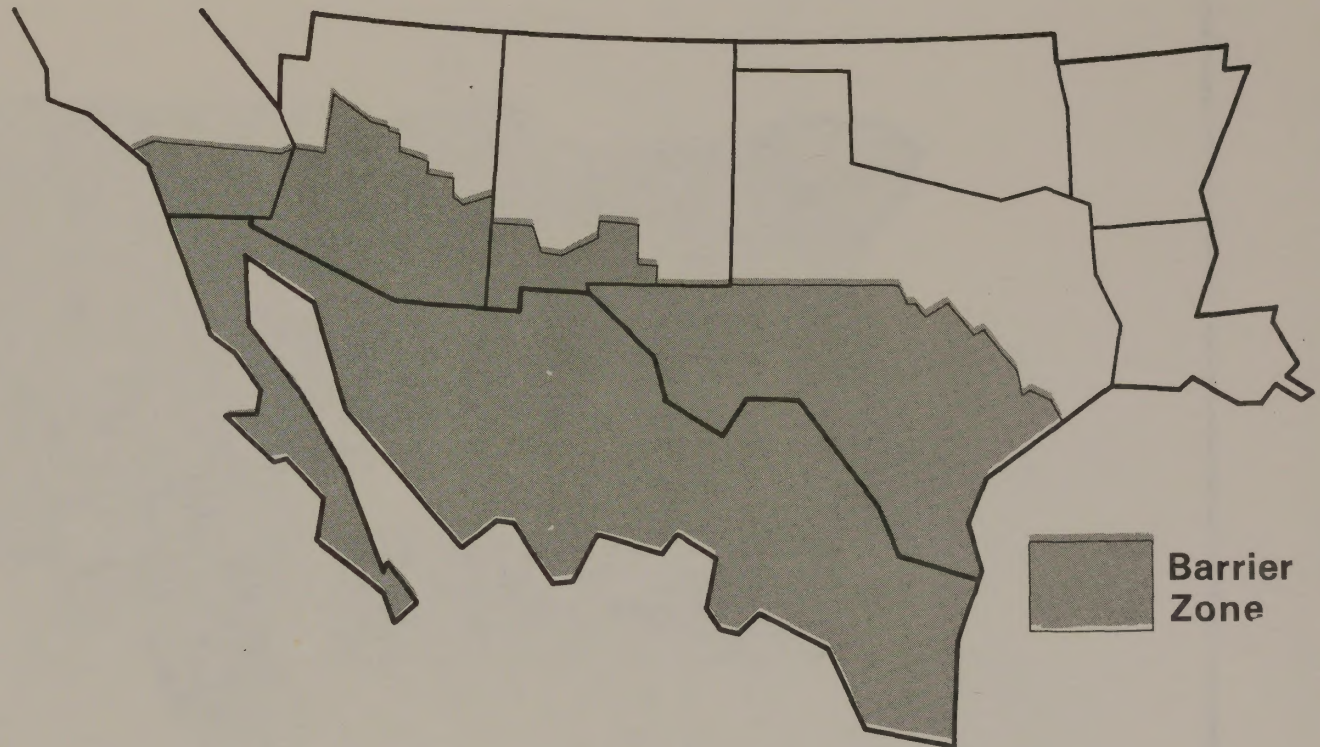
•Hot Spot



•None



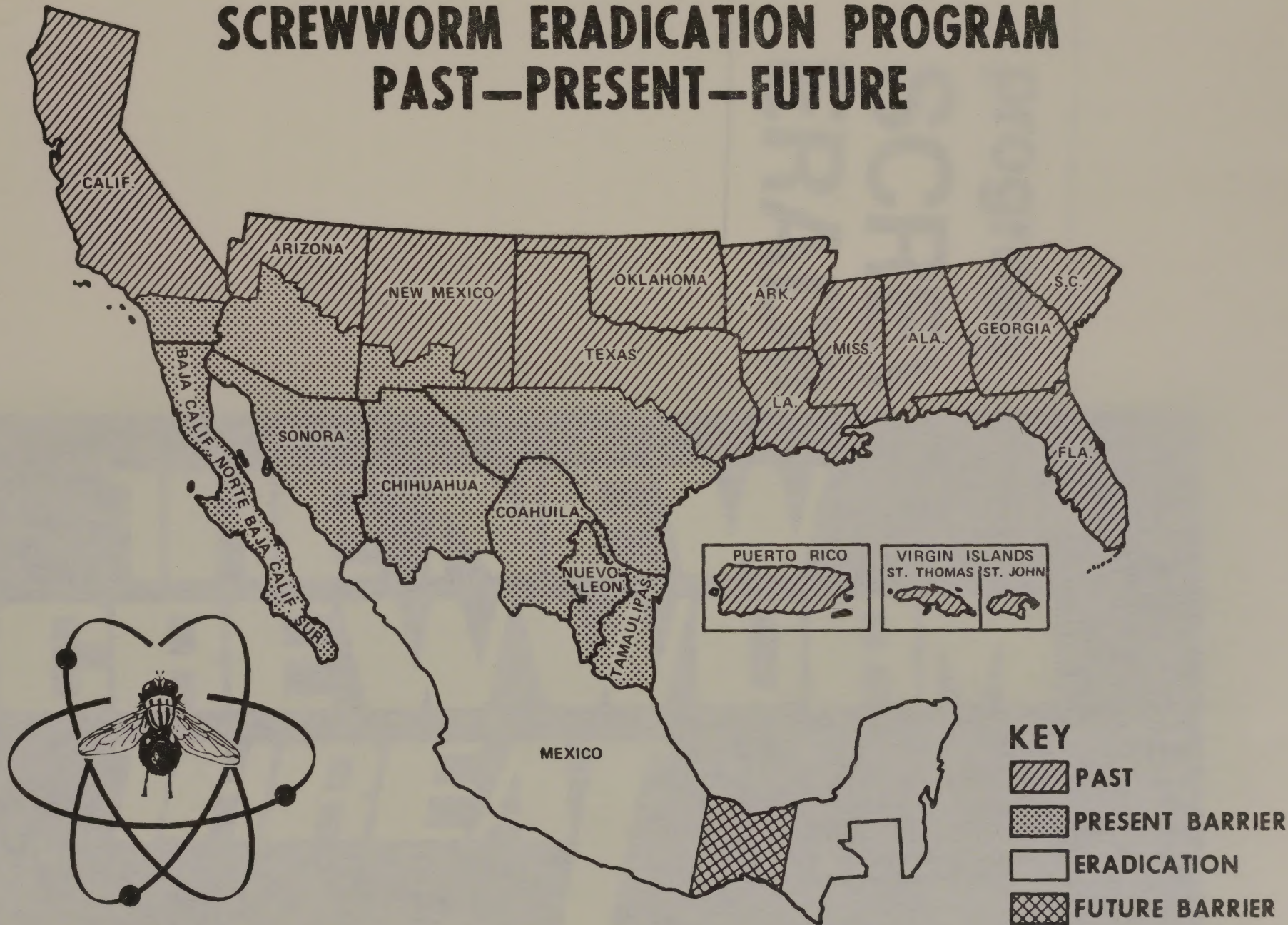
PROGRAM AREA



FACTORS GOVERNING TYPE OF FLY RELEASE

- Livestock Concentration
- Proximity of Infestation to U.S.
- Weather (Temperature, Rainfall, Humidity)
- Screwworm Population
- Season
- Husbandry Practices

SCREWORM ERADICATION PROGRAM PAST—PRESENT—FUTURE



U.S. DEPARTMENT OF AGRICULTURE

VETERINARY SERVICES

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

THE NEW SCREW WORM *THREAT*

TEXAS A&M UNIVERSITY
TEXAS AGRICULTURAL EXTENSION SERVICE
J. E. Hutchison, Director, College Station, Texas

THE NEW SCREWORM THREAT

Weldon H. Newton
Extension Entomologist
Texas A&M University

Screwworms were on the rampage in Texas and other southwestern states again in 1972. Texas livestock producers in about 240 counties reported more than 90,000 screwworm cases — by far the worst outbreak since 1962 when the Southwest Screwworm Eradication Program began (figure 1).

<u>1962</u> 49,484	<u>1963</u> 4,916	<u>1964</u> 223	<u>1965</u> 446	<u>1966</u> 1,203	<u>1967</u> 835
<u>1968</u> 9,268	<u>1969</u> 161	<u>1970</u> 92	<u>1971</u> 444	<u>1972</u> 90,000+	

Fig. 1. Number of screwworm cases reported in Texas since eradication program began.

Eradication officials attribute the 1972 outbreak to larger than normal overwintering populations which exploded during late winter and early spring. Favorable moisture and temperature conditions in late summer and fall of 1971 allowed larger population buildups further north in the state than usual. This was followed by an unusually mild winter which allowed screwworms to survive far north of their normal overwintering range. Heavy screwworm activity in northern Mexico also continued during the winter to provide a menacing source of flies with the potential to overwhelm intensive eradication efforts.

The eradication program since 1962 has saved Southwest livestock producers more than \$1 billion in losses. Although 1972 was a serious setback, officials are optimistic that winter conditions have eliminated screwworms from most of the Southwest and reduced their overwintering range to extreme South Texas and Mexico where populations can be effectively restricted during 1973. With favorable weather and conscientious producer cooperation, all or most of Texas and the Southwest can again be free of screwworms during 1973.

THE SCREWORM MENACE

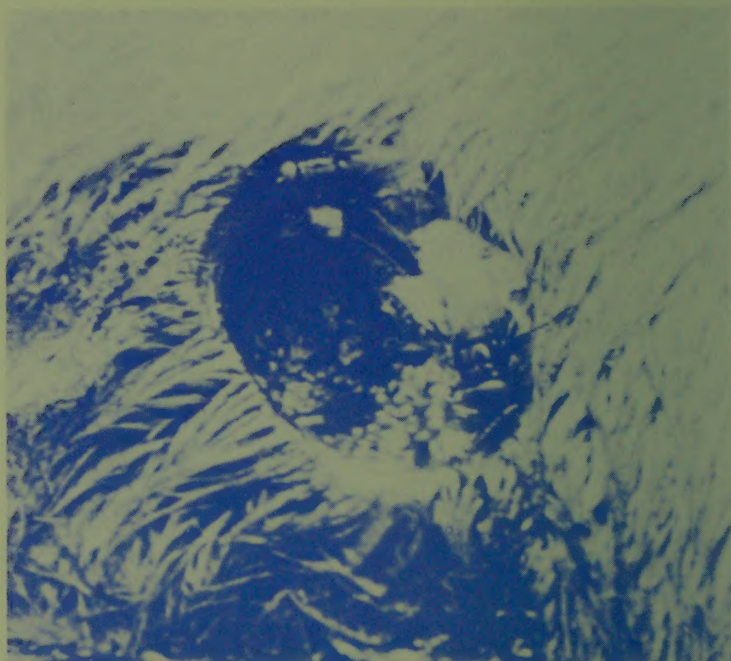
The screwworm, the maggot of one of a group of insects commonly called blow flies, infests practically all kinds of wild and domestic animals, poultry and man, but is more common among cattle, hogs, deer, sheep and goats. Screwworms infest only wounds of warm-blooded animals and attack only living flesh. Some maggots infesting these wounds may be from other blow flies which breed in carcasses. Carcass-breeding maggots usually are found feeding on soiled wool or in wounds containing decaying blood and tissue.



The screwworm fly, about twice as large as a housefly, is bluish-green with three longitudinal black stripes on its back.

The screwworm fly is about twice the size of a housefly and is bluish-green with three dark stripes on its back. Full-grown screwworm maggots, about $\frac{3}{4}$ inch long, have noticeable rows of spines that surround their bodies, giving them the screw-like appearance from which their name is derived. The front end of the screwworm tapers and contains the mouth hooks.

The true screwworm is distinguished from common blow fly maggots by the presence of two dark parallel air tubes. These tubes in full-grown screwworm maggots are readily visible with the naked eye, but are scarcely visible in common blow fly maggots. Most common blow fly maggots have white, yellow or gray colors. Screwworms have a pinkish tinge when they have completed feeding and are about ready to leave the wound. The only sure way to identify a screwworm case, however, is to collect maggots for microscopic examination by a specialist. Collection kits



Screwworm-infested wound with flies and egg mass.

are available from county Extension agents. Ten or more maggots should be collected from the wound and submitted to the **SCREWORM ERADICATION LABORATORY**, P.O. BOX 969, MISSION, TEXAS 78572.



Mature screwworm larvae extracted from an infested wound.

Life History

The screwworm has four developmental stages: egg, larva (maggot), pupa and adult fly. A female fly may produce up to 3,000 eggs which she deposits on wounds in masses of 200 to 400 each during her lifetime of 2 to 4 weeks. Within 12 to 24 hours, eggs hatch into maggots which feed on the flesh for 5 to 7 days and then drop out of the wound to pupate $\frac{1}{2}$ to 1 inch below the soil's surface. In warm weather, flies emerge from pupae after 7 to 10 days and work their way to the soil's surface. During the first few days of their adult life flies feed on the liquids of manure, meat and exudate from wounds, as well as nectar and plant juices. Flies usually mate when they are 2 days old. Females mate only once, but the males mate several times. After females are 5 to 6 days old, they seek wounded animals on which to deposit their eggs. About 21 days are required for the screwworm to complete a life cycle.

Nature of Damage

Maggots feed with the tapered head deep in the wound with only the blunt hind end exposed for breathing. The screwworms continually tear and rasp away living flesh, gouging out deep wounds which exude a brownish, bloody discharge. The maggots usually feed so deeply that only close observation reveals them projecting just above the surface of the bloody discharge. The bloody, characteristically foul-smelling wound attracts additional flies which deposit more eggs on or near the wound; consequently, thousands of maggots may infest a single wound. Single, neglected infested wounds can cause death of young animals and are often fatal in grown animals also.

SCREWWORM ERADICATION PROGRAM

Since 1962, the U.S. Department of Agriculture laboratory at Mission has produced and mass-released sterile screwworm flies, the males of which mate with native females. Because the native females mate only once, overwhelming native males with massive sterile male releases results in eventual self-annihilation since eggs laid by native females mated to sterile males do not hatch. When native populations are at low levels, chances for sterile mating are very *high*. On the other hand, when native populations are high, chances for fertile matings are *high*.

Two hundred million screwworm flies are produced at the Mission laboratory each week. Maggots are produced

in large rearing vats and the pupae are collected at the end of the larval development period. The pupae are then exposed to sterilizing doses of atomic radiation from a Cobalt 60 source, packaged in cartons and stored until adult flies emerge. Flies are then distributed at carefully calculated release rates at required intervals in infested areas where the sterile males mate with native, fertile females. If native infestations are low, an outbreak can be brought under control in a matter of weeks. The larger the native outbreak, the more difficult it is to eliminate screwworms through sterile male releases.

WHAT YOU CAN DO

Each treated or prevented screwworm case can avert the development of several hundred screwworm flies, each of which can infest several additional animals. Just one unnoticed or untreated case can produce enough flies to severely infest an entire area. The seriousness of the 1972 outbreak demands that all livestockmen and pet owners take the following action:

1. Inspect animals at least twice a week for wounds. Treat all wounds and navels of new born animals with a protective material^{1/} regardless of whether they are infested.
2. Postpone animal surgery until cold weather when screwworms are inactive. If surgery absolutely must be performed, treat wounds thoroughly with a screwworm protectant^{1/}, inspect daily until completely healed and retreat wound as necessary.



Screwworm pupae develop $\frac{1}{2}$ to 1 inch below the soil's surface.

3. Spray animals every 2 to 3 weeks until cold weather, if possible, with preventive sprays containing 0.25 percent coumaphos (Co-Ral®) or 0.5 percent ronnel (Korlan®)^{1/}. These materials also control horn flies, ticks and lice and help to reduce populations of stable flies and horse flies. These treatments also control screwworms which might be undetected in small or obscured wounds.
4. Spray animals with one of the above materials before shipping to another area as a preventive measure against spreading possible infestations.
5. Upon receipt of livestock shipments from other areas, check each animal thoroughly for wounds or screwworm infestations. Treat all wounds and observe daily until healed.
6. If worm-infested wounds are found, collect a sample and mail to the Screwworm Eradication Laboratory, Box 969, Mission, Texas 78572. Eradication officials *must* know where and how many screwworms cases are occurring to properly plan sterile fly release programs.

Wound Treatments

Several screwworm remedies and wound protectants are available commercially from livestock and veterinary

¹ *Note: All insecticides on livestock must be used in strict accordance with label precautions and restrictions. Carefully read and follow the product label before using to avoid possible contamination of meat or milk or animal injury.*



Protective treatment of navels of new-born animals is a must during screwworm outbreaks.

supply outlets. These materials, sold under several brand names, are formulated as viscous smears, dusts, liquids and pressurized aerosols. Insecticides commonly used in these formulations include coumaphos (Co-Ral®), ronnel (Korlan®) and lindane. Restrictions on using these materials vary according to the class of livestock being treated. Be sure to thoroughly read the product label to determine whether it is appropriate for your use and follow any other restrictions listed.

Prevent Livestock Injuries

Protruding nails, barbed wire, obstacles or crowded conditions increase chances of livestock injuries which invite screwworm attack. Protect your animals by eliminating any conditions that might cause unnecessary cuts or scratches.

Support the Eradication Program

Practice good livestock management. Follow preventive measures. Inspect your herds regularly. Collect and report suspected screwworms. Treat all wounds and infestations. Encourage your neighbors to do the same. *Your full cooperation can prevent screwworm outbreaks and provide necessary support for sterile fly releases.*

* * * * *

For additional information or assistance, contact your local county Extension agent or the Extension entomologist, Texas A&M University, College Station, Texas 77843.

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Cooperative Extension Work in Agriculture and Home Economics, Texas A&M University and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.



**INSPECT
COLLECT
TREAT**

your animals regularly
larvae for identification
wounds and infestations



PROTECT LIVESTOCK, PETS, WILDLIFE!

THE SOUTHWEST SCREWORM ERADICATION PROGRAM

Releases billions of sterile screwworm flies, which stop natural reproduction by mating with fertile native flies;

Maintains a screwworm barrier zone, by means of sterile fly distribution, to prevent the spread of screwworms from Mexico into the United States;

Identifies all larvae sent to the Southwest Screwworm Eradication Laboratory, Mission, Tex., or submitted through State agencies;

Provides special intensive treatment for areas with confirmed screwworm infestations;

...and asks your full support—

PREVENT SCREWORMS!

STOP SCREWWORMS

EIGHT STEPS *YOU* CAN TAKE TO HELP STOP SCREWWORMS

1. **INSPECT** animals regularly for cuts, scratches, and wounds.
2. **MANAGE** livestock to reduce injuries.
Avoid surgery in warm seasons.
3. **COLLECT** larvae and egg masses for identification. Search deep in wounds for screwworms. In Texas send samples to: Screwworm Eradication Program, Box 969, Mission, Texas 78572. In other States send to appropriate State animal health laboratory.
4. **TREAT** wounds with an approved preparation labeled for this purpose.
5. **SPRAY OR DIP** herds with approved pesticides. Follow directions on the label.
6. **OBSERVE** restrictions on livestock shipments.
7. **KNOW** for sure that purchased animals are screwworm-free **at point of origin**.
8. **TELL** your neighbors about the screw-worm threat. Encourage them to follow these precautions.

Reinspect wounds until healed.

Veterinary Services
Animal and Plant Health Inspection Service
U.S. Department of Agriculture
MAY 1972

progress in **SCREW WORM ERADICATION**

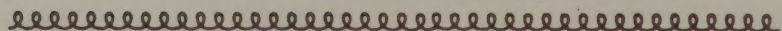
APHIS 91— 25
October 1974

**ANIMAL AND
PLANT HEALTH
INSPECTION SERVICE**

**UNITED STATES
DEPARTMENT OF
AGRICULTURE**

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This publication supersedes ARS 91-61-1, "Questions and Answers on Keeping Screwworms Out of the United States," September 1969 and ARS 91-64-1, "Facts About the Screwworm Barrier Program," October 1969.

PROGRESS IN SCREWORM ERADICATION

Screwworms are the larvae, or maggots, of the screwworm fly. They are a serious pest of warmblooded animals—livestock, pets, wildlife, and even humans. They closely resemble common blowfly maggots. But unlike blowfly maggots—which feed on carrion or dead or diseased tissue—screwworms consume the healthy flesh of the warmblooded animals they infest.

Screwworms are found in open untreated wounds. The female fly lays a mass of eggs on the edge of a wound. Larvae hatch from these eggs and burrow into the flesh, where they feed. Mature larvae drop to the ground and pass through their pupal stage in the soil. Later—usually in about 10 days, but sometimes as much as 60 days, depending on the weather—they emerge from the soil as flies. Within days the flies mate, and begin infesting livestock with a new generation of screwworms.

Screwworms seriously injure, maim, or kill infested animals, particularly if wounds are untreated and become reinfested. Screwworm larvae feed continuously. They grow from nearly microscopic size to about one-half inch in length, and in the process greatly enlarge the wound. This destructive parasite was a major pest throughout the southern and southwestern States, and today is still found in Mexico, Central and South America, and the Greater Antilles Islands.

The destruction caused by screwworms has been greatly reduced in the United States and in parts of Mexico—in comparison with what it was before the cooperative eradication program was initiated using a unique technique.

Scientists of the U.S. Department of Agriculture (USDA) artificially raise millions of screwworm flies, and make them sexually sterile by exposure to atomic radiation. The sterile flies are then released over infested rangelands, where they mate with the native fertile screwworm flies. Eggs from such matings will not hatch. Since the female screwworm fly usually mates only once in her lifetime, screwworm reproduction is stopped entirely when there are enough sterile males to mate with all fertile females.

The sterile male eradication technique was first used successfully in a pilot project on the Caribbean island of Curacao. It then was successfully applied in the southeastern and southwestern United States, and in the Virgin Islands. The continuous release of sterile flies throughout the United States-Mexico border area creates a barrier zone against migrating screwworm flies that might reinfest the United States.

Now, under an international agreement signed August 28, 1972, the United States and Mexico are extending screwworm eradication efforts southward in Mexico to the Isthmus of Tehuantepec. There, a new and more effective barrier zone will be established maintained—by continuous sterile fly release—to protect the North American continent against future screwworm migrations.

Screwworm eradication programs, past and present, have succeeded only when the sterile flies greatly outnumber the native fertile flies. But this favorable sterile-to-fertile ratio can be achieved only when livestock owners support the eradication program with their own efforts. They must help prevent infestations by refraining from wounding animals during screwworm seasons, by spraying with preventative materials, by treating all wounds and infestations, and by submitting samples of larvae from infested wounds for identification by trained program specialists. Every step taken to prevent, eliminate, or report a screwworm case reinforces the overall program to eradicate screwworms.

The Screwworm and Its Past

The screwworm fly is known scientifically by the name *Cochliomyia hominivorax* (Coquerel), but not until 1933 was any clear distinction made between this parasitic insect and the common blowfly species *Cochliomyia macellaria* (Fabricius), which had been known since the late 18th century. For over a hundred years, it had been assumed that maggot infestations in living animals were those of blowflies, feeding on the decaying tissues around wounds and sores—just as blowflies feed on the carcasses of dead animals. These larvae, or maggots, were called screwworms because of the circular rows of spines around their bodies, which made them resemble the common wood screw.

Screwworm infestations in living animals were reported in the Western States as early as 1825. Destruction caused by the pest increased over the years to the point where livestock production became unprofitable in some areas. Home remedies for treating infestations were ineffective. By the turn of the century, ranchers were appealing to the Government for help.

The U.S. Department of Agriculture started research on screwworms in 1913, but these early studies failed to show the distinction between the parasitic and non-parasitic infestations, just as the earlier home remedies had failed to stop the pest. Realizing the need for increased efforts, the USDA Bureau of Entomology and Plant Quarantine in 1929 established a research station at Menard, Tex., under the direction of entomologist Emory C. Cushing. This station was subsequently moved to Kerrville, Tex., and expanded.

At the new research station, insect toxicologists and entomologists concentrated on measures to protect wounds against screwworms—an effort that advanced rapidly when the team developed a way of artificially rearing large numbers of screwworms, thereby obtaining an adequate test population. Among the various toxic chemicals tested, No. 62—diphenylamine—proved the most effective as a wound dressing. When dissolved in benzol and thickened with a turkey-red-oil wetting agent, this became an effective larvacide. The preparation was further stabilized with the addition of lampblack, and became the well-known “Smear 62”—for years the standby preparation for treating screwworm infestations. Organophosphorus compounds have replaced Smear 62 in recent years, but this preparation marked the first significant relief from screwworms.

Even with an effective wound dressing, however, screwworm infestations continued. Constant vigilance was needed to protect livestock. The trapping of immense numbers of blowflies over several years brought no appreciable reduction in the number of infestations. At this point, Director Cushing concluded that somewhere in the research some vital information about this livestock pest had been overlooked and that a complete review of its ecology was necessary.

Cushing undertook a course of graduate studies in medical entomology in England at the University of Liverpool School of Tropical Medicine. Under the direction of Professor W. S. Patton, he collected and studied samples of the various species of American blowflies. Although externally the flies appeared identical, he observed distinct differences between the sexual organs of the blowfly *C. macellari* and those of flies reared from maggots found in infested wounds. Thus in 1933, the culprit was at last identified and given the name *Cochliomyia americana*, subsequently changed by other specialists to *C. hominivorax*.

Identification of this parasitic blowfly species came none too soon. By that time, livestock shipments during the drought years had spread screwworms to Florida and other Southeastern States, where they caused heavy losses among livestock, pets, and wildlife. As in the Southwest, even humans occasionally became infested. Livestock production in the Southwestern States had come almost to a standstill because of the immense screwworm population.

Research on an effective method of screwworm control or eradication was suspended during World War II, but resumed immediately thereafter under a team of entomologists that included Dr. E. F. Knipling, Dr. R. C. Bushland, Dr. A. W. Linquist, A. H. Baumhover, and A. J. Graham. D. E. Hopkins, Frank Dudley, Weston New and other technicians also assisted.

It was observed that the female screwworm fly usually mates only once in her lifetime. This mating fertilizes all eggs that she will subsequently produce. Dr. Knipling proposed that if large numbers of male screwworm flies could be sexually sterilized and distributed throughout infested areas, natural reproduction would be stopped by the mating of sterile males with fertile female flies, which would lay sterile eggs.

An intensive search was launched to find an effective and economical means of sterilizing large numbers of male screwworm flies. Dr. Bushland and Mr. Hopkins discovered that screwworm pupae, just before they develop into flies, could be sterilized by exposure to X-rays. Further research, with assistance from the Atomic Energy Commission, showed that sterility could be produced through exposure to gamma rays, using Cobalt-60 as a radioactive source.

Eradication

Research provided the foundation for control or eradication of screwworms. Now the time had come to see if the theories would work in practice. USDA scientists sought out an infested place that was isolated by natural barriers from other infested areas, so that the problem of reinfestation by migrating flies could be eliminated from the experiment. In 1954, the Dutch West Indies Island of Curacao, 50 miles off South America, was selected for a screwworm eradication experiment. The release of sterile screwworm flies over the island had the predicted effect. Screwworm egg masses, collected from wounded animals, showed a rising percentage of sterile masses compared with those that were fertile. The number of infestations dropped steadily, and after four months no more egg masses could be found and no infestations were reported. Curacao became the first place to be freed of the screwworm menace and it is still free today.

Success of the eradication experiment in Curacao excited the interest of southeastern livestock producers. If screwworms could be eliminated within a small isolated area, could they not

be eradicated over a large isolated area—such as the Southeastern United States? Until 1933, the Southeastern States had been free of screwworms. The movement of infested cattle into southern Georgia gave screwworms the free ride they needed to spread into Florida, where they became established and survived the year-round. From then on, they were a major pest of the region, often ranging northward during the warm seasons into all the Southeastern States.

In 1957, preliminary tests in Florida showed promising results. The Florida legislature appropriated \$3 million to defray part of the costs of a statewide screwworm eradication program to be conducted in cooperation with the U.S. Department of Agriculture over a two-year period. This effort was further supported by Georgia, South Carolina, Alabama, and Mississippi in a region-wide cooperative program authorized by Congress, which began in 1958 under joint direction of USDA's Agricultural Research Service and the Florida Livestock Board.

The massive number of sterile flies needed for the southeastern screwworm eradication program was provided by a sterile fly production plant, constructed at Sebring, Fla. For the first time, a parasitic flesh-eating insect was mass-produced and sterilized in an industrial type of operation. Twenty aircraft were used to disperse the sterile flies from small cardboard boxes. Livestock inspection stations were established along the Mississippi River to keep the area from being reinfested by the movement of infested livestock from the West. Producers cooperated by inspecting their animals, treating wounds, spraying their herds, and sending in samples of maggots for identification so that program officials could know the location and severity of screwworm infestations.

By the end of 1959, the Southeast was free of screwworms. Total costs of the 2-year campaign amounted to about \$11 million—compared with annual \$20 million losses caused by screwworms in the Southeastern States.

Success of the screwworm eradication program in the Southeast led western ranchers to request similar efforts in their region. Elimination of this destructive pest would relieve the region of an estimated loss in excess of \$100 million annually. For the first time in more than a century, there was hope that the United States could be free of this destructive pest.

But the hope of screwworm eradication was clouded by several problems not present in the isolated southeastern region. Screwworm overwintering areas in the Southwest were larger, and they extended continuously southward into Mexico. Screwworm migrations across the 2,000-mile U.S.-Mexico border presented a tremendous potential for reinfestation. Climatic conditions in the arid Southwest and the large numbers of livestock were entirely different from the situation faced in the Southeast.

Nevertheless, State and Federal officials decided to go ahead with the Southwest Screwworm Eradication Program—with authorization by Congress and the wholehearted support of the livestock industry. In addition to Federal and State appropriations, southwestern livestock producers voluntarily raised \$4.5 million to eradicate screwworms, donated through the Southwest Animal Health Research Foundation (SWAHRF).

The southwestern eradication program began in February 1962. It had two principal objectives: (1) Eradicate the screwworm fly from overwintering areas of the Southwest; and

(2) establish and maintain a screwworm barrier zone along the U.S.-Mexico border through the year-round release of sterile flies to stop northward migrations of the pest.

A sterile fly production plant was constructed at the former Moore Air Base at Mission, Tex., largely from funds donated by SWAHRF. Federal expenditures were matched by those of the five States comprising the original eradication area—Texas, New Mexico, Arkansas, Louisiana, and Oklahoma. The new plant was fitted out for the rearing of more than 150 million sterile flies per week, drawing heavily on the experience gained in the southeastern eradication effort.

As in the southeastern eradication program, success was tied closely to the support provided by ranchers in the management of their livestock. In order to reduce the number of fertile native screwworm flies to the lowest possible level—giving the sterile flies a better chance to compete—livestock producers were asked to check their animals regularly, to treat every wound and infestation, and to send in samples of the maggots they found in wounds.

The eradication program proved an outstanding success. By September 1963, screwworm infestations within the original five-state area had been reduced by 99 percent, and an artificial barrier zone had been established along the Rio Grande through the cooperation of the Mexican Government. This zone was extended along the entire 2,000-mile border when Arizona and California joined the program in 1965.

By 1964, screwworms had been eradicated from the original five-state eradication area, and by the end of 1966 the last self-sustaining screwworm populations had been eliminated in the Arizona and California overwintering areas.

The Barrier Zone

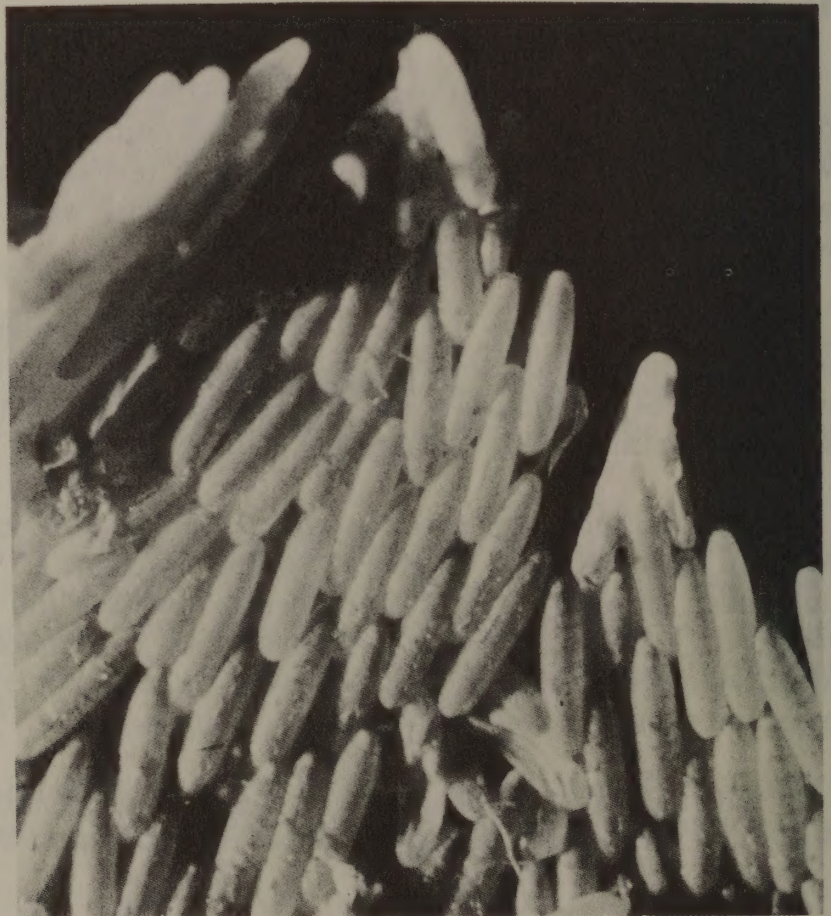
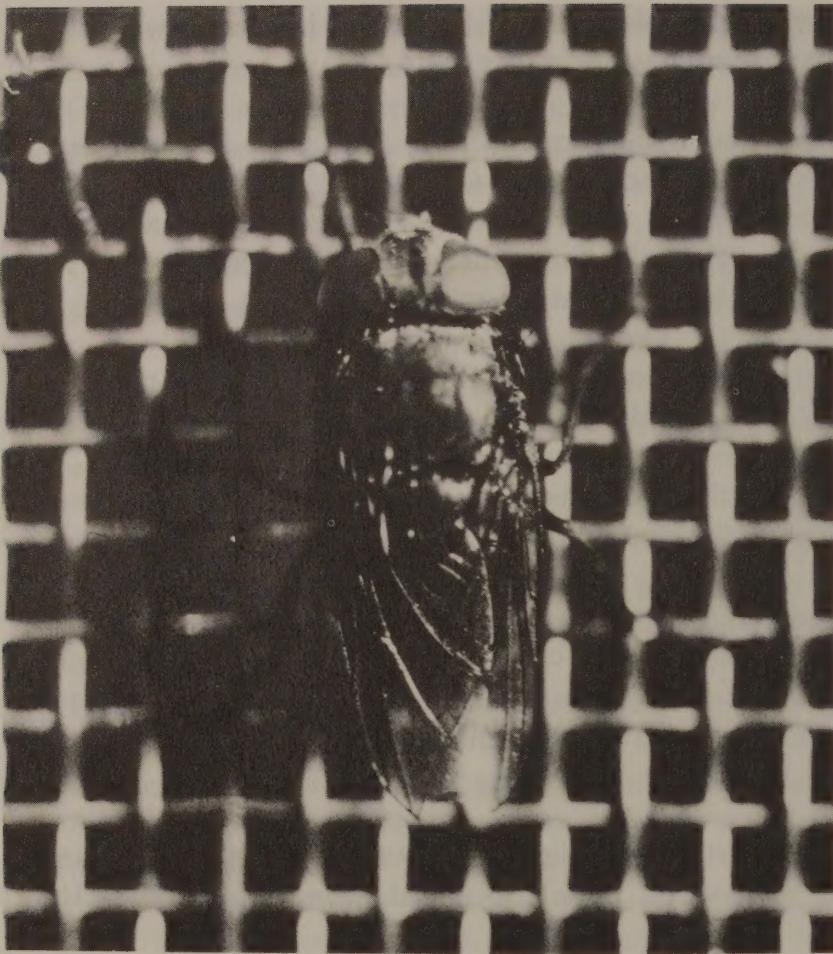
Screwworm eradication in the Southwest did not guarantee the region against annual reinfestations when screwworm flies migrated northward from Mexico. The screwworm barrier zone was established to prevent or minimize such reinfestations which would occur unless sterile flies were released constantly wherever screwworms were reported or their migrations could be reasonably anticipated.

The barrier zone operated on the sound strategy of (1) maintaining surveillance and screwworm prevention throughout the region, (2) reporting all suspected cases by submission of worm samples or egg masses, and (3) the aerial release of sterile flies over all infested areas and every site of a confirmed screwworm case.

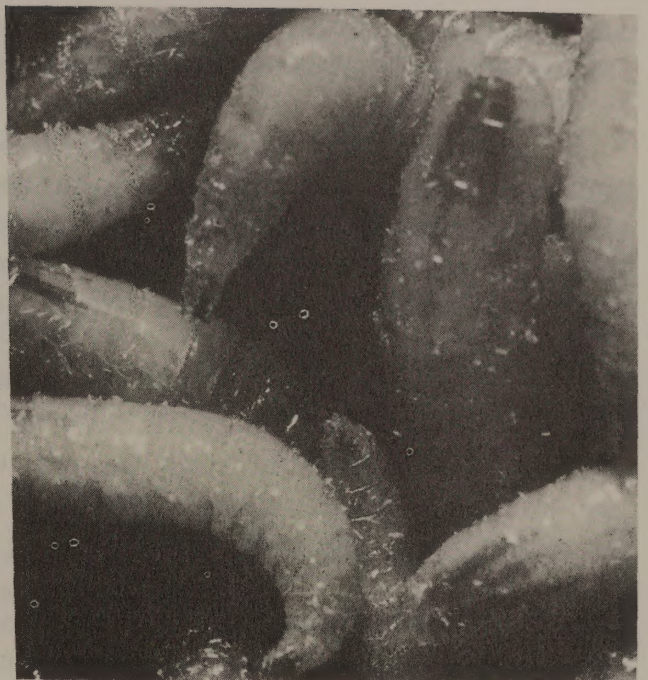
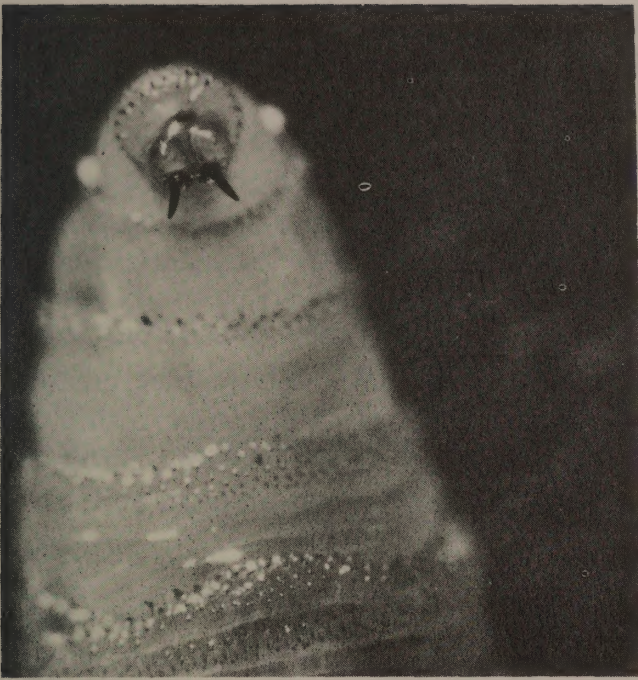
Cooperation by ranchers, veterinarians, county agents, livestock inspectors and others was an essential element of a successful barrier program. If wounds became infested and remained untreated, screwworms could build up to numbers too large for the continued effectiveness of sterile fly releases. If ranchers failed to send in samples of larvae or egg masses (which can be identified only by experts), program officials could not trace the spread and buildup of screwworm cases and plan effective sterile-fly release patterns.

The necessity for a barrier zone was obvious, considering that a screwworm fly can travel—at least—180 miles under its own power to find and infest a suitable host animal. A single infestation

ADULT FLY



EGGS



LARVAE



PUPAE

can produce more than three hundred flies within 21 days. And any warmblooded animal with an untreated wound—even as small as a tick bite—is a potential host for this deadly parasite.

The barrier zone worked exceptionally well. Screwworm cases, which once numbered in the millions, dropped to only a few hundred cases every year. Even after the threat of massive infestations had passed, many ranchers remained alert to the possible danger, especially when cases were reported within nearby counties. Worm samples continued to come in to the plant at Mission so that screwworm eradication treatments could be made wherever necessary.

Problems did arise in 1968, however, when unusually moist and mild weather created conditions ideal for screwworm survival and spread. Nearly 10,000 cases occurred within the Southwestern States. Although this was only a fraction of the numbers that occurred before the program, it served to remind everyone of the continuing danger whenever screwworms built up to large numbers in Northern Mexico.

The hardest blow to the barrier zone program occurred in 1972 when some of the wettest weather on record in Northern Mexico caused screwworms to build up to a record level in early spring. The predictable migrations occurred to such an extent that the sterile flies could not overwhelm the fertile population to the degree necessary to halt their reproduction. The difficulties were compounded by a lack of cowboys and laborers necessary to treat all the infestations; thus many animal wounds remained untreated and added to the already epidemic numbers of screwworms.

Special regulations were issued requiring the inspection and certification of all livestock moving interstate from the infested areas. Spraying or dipping was required for shipments to the Southeastern States. The dispersal of sterile flies had to be limited to the areas where they were most needed—on the eastern edge of the outbreak area and in the southern border areas where potential overwintering populations had to be reduced before the advent of winter.

The toll from screwworms in 1972 exceeded 95,000 confirmed cases in 11 States. Even the regulations against shipping screwworm-infested animals did not prevent a few cases from appearing in several Southeastern States. These infestations were eradicated by emergency release of sterile flies and by extensive inspection and spraying operations in each outbreak area.

The disastrous 1972 season demonstrated clearly the need for a more effective barrier zone. This could best be established across the narrow Isthmus of Tehuantepec in Southern Mexico, following an eradication program throughout the northern two-thirds of that country. This proposal, which had been discussed for years, is now moving toward reality with the establishment of a joint program by the United States and Mexico for the eradication of screwworms.

The Joint Mexico-U.S. Screwworm Eradication Program

On August 28, 1972, in Mexico City, U.S. Secretary of Agriculture Earl L. Butz and Mexican Secretary of Agriculture and Livestock Manuel Aguirre signed the international agreement authorizing a joint Mexico-U.S. Commission on Screwworm Eradication. The Commission is directed by a director and co-director, representing Mexico and the United States, respectively. Four other Commission members are appointed from Mexico and four from the United States.

Eighty percent of the funding is to be from U.S. sources and 20 percent from Mexico. Commission headquarters are located in Mexico City at Liebnitz #20, Colonia Nuevo Anzures, Mexico 5, D.F., Mexico.

In many ways administration of eradication efforts is to be patterned after a previous joint program to eradicate foot-and-mouth disease from Mexico. A new sterile fly production plant is being constructed near Tuxtla Gutierrez in the Isthmus of Tehuantepec from which 300 million sterile flies will be distributed weekly throughout Mexico. The 200-million-weekly fly production from the Mission, Tex., plant will be released from the U.S.-Mexico border southward. The program is estimated to take from five to seven years. After eradication, the barrier zone will be maintained across the Isthmus at approximately one-fourth the cost necessary to maintain the present zone along the United States-Mexico border.

Implementation of the U.S.-Mexico screwworm eradication program is moving ahead. The Mexican plant is being constructed at Tuxtla Gutierrez, Chiapas, in Mexico to extend sterile fly releases as necessary from the U.S. border to the Isthmus of Tehuantepec.

The Screwworm Plant at Mission, Tex.

The Southwest Screwworm Eradication Program and the expanded eradication activities in Northern Mexico are directed by USDA's Animal and Plant Health Inspection Service (APHIS) from the sterile fly production plant at Mission, Tex. Since 1962, this facility at the former Moore Air Force Base has served as the focal point for receiving reports of screwworms in the southwestern States; the mailing address is: Southwest Screwworm Eradication Program, APHIS, U.S. Department of Agriculture, Box 969, Mission, Tex. 78572.

The artificial raising and distribution of 200 million sterile screwworm flies each week is a highly complex operation that has taxed the abilities of entomologists, engineers, pilots, veterinarians, and administrators; yet the result of their efforts is a highly efficient industrial operation that has operated around the clock, seven days a week, since the start of the program. Some 400 employees, working three shifts, collect and propagate fertile screwworm eggs, feed the larvae, store the pupae, irradiate them at the proper time, and package the sterilized flies for release from the program's fleet of aircraft.

The plant, which has over 81,500 square feet of floor space, is sealed tightly against any possible escape of fertile flies or contaminated material to the outside. All employees and visitors must change into uniforms and pass through a special security section in order to enter the plant; they must shower before leaving. All materials must be incinerated or "sterilized" before leaving the plant. Heavy hardware must pass through a special "hot room" before it may be removed.

The operation of the plant involves many refinements that have been developed over the years since the first plant was constructed at Sebring, Fla. The eggs from which the larvae are hatched are obtained from the fertile fly colony. Eggs hatch and larvae feed in warm, shallow vats on a medium simulating the flesh of warmblooded animals. The mature larvae crawl from the vats, fall into channels of flowing water that carry them to a separator. They are then placed in sawdust-filled

boxes for pupation. Pupae are then separated from the sawdust and held in a temperature- and humidity-controlled room for about 6 days. At the proper age they are placed in locked metal cannisters for radiation. The pupae receive approximately 7,000 roentgens of gamma radiation emitted from radio-active Cobalt-60 or Cesium-137. Cannisters of irradiation pupae are conveyed automatically to the packaging section where the pupae are measured into cardboard release boxes. The boxes, ejected from aircraft, release the adult flies that have emerged from their pupal cases.

Field Survey and Identification, Methods Development, Plant and Aircraft, Maintenance and Administrative Sections are all important parts of the total program, in addition to the sterile fly rearing operations.

Flies are released from the aircraft through specially constructed chutes that eject and open the boxes at predetermined rates. Normally, the planes fly on parallel routes, or swaths, approximately 5 to 10 miles apart. Other aircraft fly "hot-spot" and "strategic" sterile fly release missions. These operations are supported by livestock inspectors who visit ranches in the infested areas, marking the sites for aircraft where necessary, and encouraging ranchers to inspect their livestock, spray their herds, and submit larvae samples for identification. The importance of owner cooperation and screwworm-preventing husbandry practices cannot be overemphasized. Sterile flies alone will not eradicate screwworms.

What the Public Can Do

Before screwworm eradication, ranchers were alert for screwworms. That policy should be just as valid today. Every infestation that is prevented or treated increases the potential effectiveness of the sterile screwworm flies. Every infestation that goes unreported is an opportunity for screwworms to build up undisturbed until they reach menacing numbers.

The following measures are recommended for the maximum effect in preventing or eliminating screwworms.

1. Inspect animals at least twice a week. Screwworm larvae reach maturity in less than seven days.
2. Treat every wound with an approved preparation.
3. Spray animals when screwworm danger is high, and after livestock surgery or shearing of sheep and goats.
4. Collect larvae or egg masses that are found in or near wounds, and send them in for identification. Free mailing kits are available from State and Federal livestock inspectors, veterinarians, county agents, and at locations such as livestock markets, feed stores, and animal health offices.
5. Avoid surgery during seasons of high screwworm danger. Branding, dehorning, castrating, docking, and shearing should be completed before screwworms build up in the spring.
6. Manage animals so as to avoid unnecessary injuries. Avoid crowding; keep gates and corrals free of protruding nails and other sharp projects.
7. Observe all regulations governing livestock movements from areas of seasonal screwworm infestations. Never move an infested animal.

Pet owners, veterinarians, and market operators can help by watching for and reporting screwworms. Eradication officials have received samples from many sources, such as hunters, zoo keepers, and medical doctors.

The Future

Success of the Mexico-U.S. Screwworm Eradication Program and the establishment of a new barrier zone at the Isthmus of Tehuantepec depend to a large extent on the support given that program by livestock producers, veterinarians, and all others involved in the keeping or handling of animals. Regardless of location, no matter how far from a barrier or eradication zone, these people must remain alert to any possible screwworm infestation. Inspection, treatment, and reporting are critical elements of eradication.

New problems will be faced in tropical Mexico; problems not encountered within the United States or the barrier zone. In some regions, rainfall totals nearly 100 inches per year and temperatures are favorable to screwworms year-round. Reliable surveys of existing screwworm conditions will be hard to obtain. Many livestock owners live in remote villages and are difficult to reach through traditional means of communications, such as newspapers or radio.

Some experience in tropical screwworm eradication has been gained through a methods development project in Puerto Rico and the Virgin Islands. USDA's Agricultural Research Service continues to study eradication methods and techniques, screwworm-fly attractants, new sterilizing techniques, and the behavior of various strains of screwworm flies. Epidemiological studies are being refined to identify environmental factors that affect the distribution of screwworms. Remote sensing studies currently being conducted may provide information about climatic conditions within the expanded eradication area.

Ranchers and animal health officials on both sides of the border now have a great incentive to push toward the successful completion of the Mexico-U.S. Screwworm Eradication Program. It is now possible to rid the North American continent of screwworms and establish a secure and economical barrier against future invasions of the pest. The experience of the past leaves no doubt that success will be well worth the effort.

Facts About Screwworms

Screwworms attack all warmblooded animals, including humans. Losses may occur as a result of death, or from crippling, weight losses, or increased susceptibility to diseases. Labor that must be provided for animal inspection and treatment, and money spent for materials for prevention or treatment of screwworm injury also represent a form of loss to livestock producers. Pet animals and wildlife, as well as domestic livestock, suffer injury or death from screwworm infestations.

The screwworm is the maggot, or larva, of the screwworm fly with the scientific name *Cochiomyia hominivorax* (Coquerel). It has been given the descriptive name "screwworm" because the larva's body somewhat resembles a wood screw.

The screwworm fly is about two times the size of a common housefly. It has a bluish-green body with three dark stripes along the back and orange-colored eyes. Rarely seen except around animal wounds, the screwworm fly is difficult to distinguish from some other blowflies.

The female screwworm fly lays eggs in batches of about 250 along the edges of open wounds. Within 12 to 24 hours the eggs hatch into tiny larvae (maggots) that burrow deeply into the wound. At this stage, the larvae are barely visible and are almost impossible to detect in a fly or tick bite, even on close inspection. Only the posterior ends of larvae protrude. With their rasping mouthparts, they tear away at the wound and feed on the exudate and flesh of the living animal for 5 to 6 days, growing to about one-half inch in length. An infested wound attracts additional female screwworm flies that lay eggs, and these multiple infestations usually cause death of the host animal, unless treated. Grown steers have been killed within 10 days.

When fully developed, larvae drop from the wound and burrow into the soil to form brown, tough-shelled puparia (cocoon) which contain the developing fly. After about a week in warm weather, screwworm flies emerge from the pupal shells. The life cycle of the screwworm averages about 3 weeks, but can be as long as 65 days during cold weather.

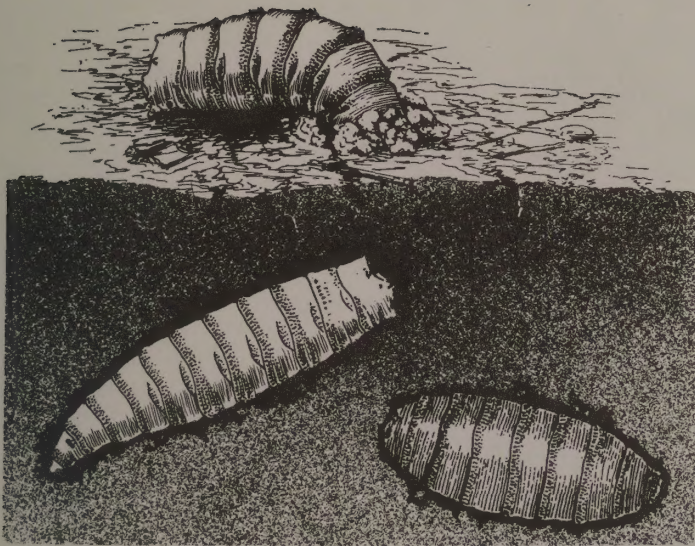
Weather is an important factor in the location, spread, and severity of screwworm infestations. Warm, humid weather is most favorable to screwworm development and activity. Extremely high or low temperatures and drought tend to limit screwworm populations and activity.

As screwworms cannot survive extreme cold, their overwintering areas are normally confined to tropical and subtropical regions. The overwintering screwworm population is likely to be larger and to extend over a much greater area following an unusually mild, moist winter than following a normally cold winter. When this occurs, the danger of reinfestation in adjacent freed areas increases.

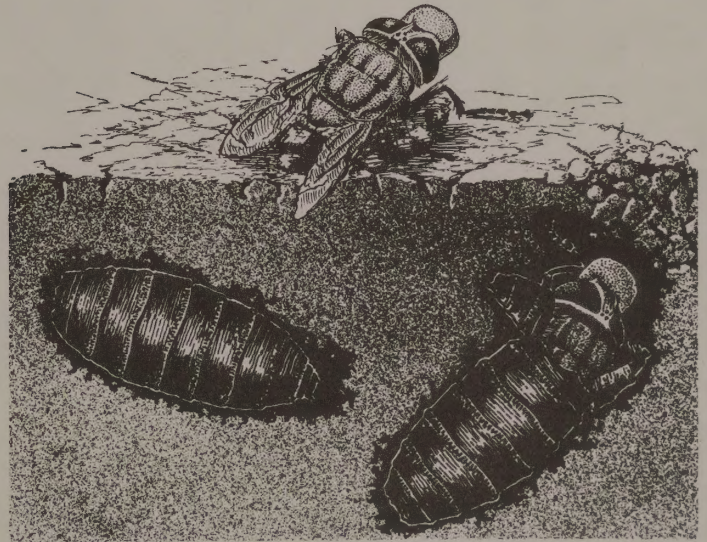
A single screwworm fly can migrate 180 miles, and may migrate as far as 300 miles from its birthplace during its lifetime. Of course, larvae may be inadvertently transported for thousands of miles through shipments of infested animals.



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Under ideal conditions, the time required for completion of the life cycle of the screwworm fly . . . from egg to larva to fly . . . averages about 3 weeks. At 6 days of age, a female fly can lay about 250 eggs on a wound. Tiny, barely visible larvae hatch from the eggs within a day and feed on the flesh for 5 to 6 days. They then drop to the ground and enter the soil where they are transformed into pupae encased in dark-colored, tough capsules. During warm weather, flies emerge from the pupal cases in about a week. The females mate in 2 to 3 days and lay eggs 4 to 6 days later.

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SCREW WORM INFORMATION



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